

DOCUMENT RESUME

ED 166 029

SE 026 333

AUTHOR Rowles, Thomas K.
TITLE Initiating the Teaching of Metrication by Means of Performance Objectives.
PUB DATE 78
NOTE 201p.; Practicum Report submitted in partial fulfillment of the requirements for the degree of Doctor of Education, Nova University
EDRS PRICE MF-\$0.83 HC-\$11.37 Plus Postage.
DESCRIPTORS Criterion Referenced Tests; *Educational Research; Elementary Education; *Elementary School Mathematics; Formative Evaluation; *Instruction; Item Sampling; Measurement; *Metric System; *Objectives; Summative Evaluation; *Teaching Techniques
IDENTIFIERS *Research Reports

ABSTRACT

This document is about a program that was proposed and initiated involving the teaching of the metric system using performance objectives for each level from first through sixth grade. A total of 45 performance objectives were used for the six grade levels. The goal for the program was to have students master 80% of the performance objectives as measured by a criterion-referenced test. Formative and summative evaluations were conducted. The results of the summative evaluation disclosed that students in all six grade levels mastered the prescribed objectives beyond the 80% level.

(MP)

* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *

ED166029

SEP 18 1978

SE

**Initiating the Teaching of Metrication
by Means of Performance
Objectives**

by Thomas K. Rowles¹

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Suzanne Kelley

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) AND USERS OF THE ERIC SYSTEM."

**Submitted in partial fulfillment of the
requirements of the National Ed. D. Program
for Educational Leaders, Nova University**

**Introductory Practicum
South Park Cluster
Submitted: April, 1978**

**¹Principal, Greenock-Mount
Vernon Elementary Schools
Elizabeth, Pennsylvania, U.S.A.**

SE 026 333

AUTHOR Rowles, Thomas

TITLE Initiating the Teaching of Metrication by Means of Performance Objectives

DESCRIPTORS Metric System; Criterion-Referenced Tests; Formative Evaluation; Summative Evaluation; Elementary Education; Item Sampling

ABSTRACT A program was proposed and initiated involving the teaching of metrication by means of performance objectives for each grade level from first through sixth grade. Each primary grade teacher was to use five performance objectives and each intermediate teacher was to use ten performance objectives. A total of 45 performance objectives were used for the six grade levels. Each teacher also received specific activities for teaching each of the performance objectives. The goal for the program was to have students master 80 percent of the performance objectives prescribed for their grade level. For testing purposes a criterion-referenced test was administered to students at each grade level using the matrix sampling technique. Formative and summative evaluations were conducted. The results of the summative evaluation disclosed that students in all six grade levels mastered the prescribed metric performance objectives beyond the 80 percent level. (Grade 1 - 96 percent; Grade 2 - 96 percent; Grade 3 - 96 percent; Grade 4 - 96 percent; Grade 5 - 92 percent; Grade 6 - 94 percent.)

TABLE OF CONTENTS

<u>CHAPTER</u>	<u>TITLE</u>	<u>PAGE</u>
	Preface	ii
I	Need for the Practicum	1
II	Research to Develop Strategy	10
III	Objectives of the Practicum	15
IV	Program Design and Implementation	21
V	Recommendations and Conclusions	41
VI	Institutionalization of Outcome	43
VII	Dissemination and Further Application of Program	44

APPENDICES

<u>Number</u>	<u>Title</u>	<u>Page</u>
A	Material and Equipment Utilized During Practicum	46
B	Photographs of Metric Activities	47
C	Teacher Formative Evaluation Form	57
D	Metric Activities Keyed to Performance Objectives	59
E	Criterion-Referenced Tests Keyed to Performance Objectives	140
F	Letter from Coordinator of E.S.E.A. Title IV-B Program	192
G	Bibliography	193

PREFACE

The Elizabeth Forward School District received approval to expend E.S.E.A. Title IV-B funds for the teaching of metrication. Unexpectedly, Governor Milton Shapp of Pennsylvania entered into litigation of the constitutionality of Act 117 which was recently passed by the Pennsylvania State Legislature. Act 117 calls for the state legislature to decide how federal monies are to be used by the state; whereas, Governor Shapp believes that deciding how to expend federal monies is an administrative duty. As a result, E.S.E.A. Title IV-B funds were withheld until January, 1977.¹ Consequently, the project was implemented in two of the six elementary schools in the school district, for which \$500.00 from the instructional supplies account portion of the school budget was available for purchasing the needed metric materials and equipment.

Further compounding the problem, Governor Shapp declared Pennsylvania a disaster area in January, 1977, because of the extremely cold weather and lack of heating fuels. The schools across the state were closed for an

¹Letter from John C. Meerbach, Ed.D., Coordinator, ESEA Title IV-B, Bureau of Instructional Support Services, October 6, 1976.

extended period of time and the educational process was temporarily truncated. The time for executing the project was somewhat delayed.

The Director of Elementary Education of the Elizabeth Forward School District, Mr. John DeSantis, supported the project and approved the purchase of metric materials and equipment from the instructional supplies account to get the program started. My colleagues, the other two elementary principals in the Elizabeth Forward School District, Miss Donna Shultz and Mr. Wesley Luckey, also supported the practicum and provided the writer with consultation from time to time.

Mr. John Cochenour, a consultant from Pennsylvania Educational Aids, Inc., assisted the teachers and the writer in selecting the proper metric materials and equipment to use when teaching the designated metric skills at each grade level. He met with the teachers during the faculty meetings in order to explain how to use the materials that were included in the Metric Labs. He also was available, upon request, for answering questions related to the use of all the metric materials and equipment that were purchased from his company.

NEED FOR THE PRACTICUM

The United States Department of Commerce, in 1971, issued a report stating that it was imperative that the nation convert to the metric system. Failure to convert, the report warned, would leave the United States isolated in a metric world and at a disadvantage in world trade.

The report also recommended that the United States change to the metric system through a coordinated national program which includes priority given to educating every American school age child. It also recommended that the conversion period be completed within a ten year period so that at the end of that time the nation would be using metric measures predominantly.¹

The students at the Greenock and Mount Vernon Elementary Schools need to learn the metric system of weights and measures. When they become adults the United States will probably have joined the other major nations in adopting the metric system. Students need to be prepared for a metric world if they are to be productive citizens. But being able to function successfully in a metric world is not the only reason why these students have learned the metric system. The metric system is better and simpler to use than the customary system. For example, a person can know the commonly used units in the metric system by

¹Brief History of Measurement Systems, National Bureau of Standards, Government Printing Office (Washington, D.C., 1972). p.4.

simply memorizing only the following:

10 millimeters (mm)	=	1 centimeter (c)
1,000 millimeters	=	1 meter (m)
100 centimeters	=	1 meter
1,000 meters	=	1 kilometer (km)
1,000 grams (g)	=	1 kilogram (kg)
1,000 kilograms	=	1 metric ton (t)
1,000 milliliters	=	1 liter (l)

Ten, 100 and 1,000 are the only numbers involved in the relation of the common metric units. This compares with the 29 numbers (many of them are multi-digit) that a child must remember to really learn the relationship of the most commonly used units of the customary system. The list below does not include such measurements as rods, fathoms, furlongs and troy weights.

Units of weight:

<u>16</u> oz.	=	1 lb.
<u>2,000</u> lbs.	=	1 ton

Units of quantity:

<u>12</u>	=	1 doz.
<u>144</u>	=	1 gross

Linear units:

<u>12</u> in.	=	1 ft.
<u>3</u> ft.	=	1 yd.
<u>36</u> in.	=	1 yd.

1,760 yds. = 1 mi.

5,280 ft. = 1 mi.

Units of area:

9 sq. ft. = 1 sq. yd.

144 sq. in. = 1 sq. ft.

1,296 sq. in. = 1 sq. yd.

3,097,600 sq. yds. = 1 sq. mi.

27,878,400 sq. ft. = 1 sq. mi.

640 acres = 1 sq. mi.

4,840 sq. yds. = 1 acre

43,560 sq. ft. = 1 acre

Units of liquid measure:

16 ozs. = 1 pt.

32 ozs. = 1 qt.

2 pts. = 1 qt.

4 qts. = 1 gal.

8 pts. = 1 gal.

128 ozs. = 1 gal.

231 cu. in. = 1 gal.

Units of dry measure:

8 qts. = 1 peck

32 qts. = 1 bu.

4 pecks = 1 bu.

2,150.42 cu. in. = 1 bu.

(That is, a struck bushel; a heaped bushel is 2,747.715 cu. in.)

If a student does not remember all of these numbers stated above she or he can determine them by computation provided she or he knows the formulas. For example, three squared or three cubed are simple computations to determine the number of feet in a square and cubic yard. However, computing square feet in a square mile by multiplying 5,280 by 5,280 is more time consuming. Furthermore, if a student is to compute the number of acres in a square mile she or he must first know the number of feet in a mile and the number of square feet in an acre. She or he must then solve the problem $\frac{5,280^2}{43,560}$, which is again time consuming and in addition offers considerable opportunity for error.

It is when determining the capacity of a cubical or rectangular container, or the weight of its contents, that it becomes apparent that the metric system is simpler to use than the customary system. Stated below in detail is a simple problem of this type worked out using both systems, in order to show the difference in the calculation involved.

Customary System

Given a cubical tank 6'9 1/2" each way, filled with water: find

- (1) the volume in cubic feet,
- (2) volume in gallons,
- (3) weight of water in pounds.

1. Convert 6'9 1/2" to inches:

Metric System

Given a cubical tank 2.07 meters each way, filled with water: find

- (1) the volume in cubic meters,
- (2) volume in liters,
- (3) weight of water in kilograms.

1. Multiply length by width by height.

$$\begin{array}{r}
 12 \\
 \times 6 \\
 \hline
 72 \\
 9 \ 1/2 \\
 \hline
 81 \ 1/2 \text{ or } 81.5
 \end{array}$$

2. Multiply length by width by height.

$$\begin{array}{r}
 81.5 \\
 81.5 \\
 \hline
 4075 \\
 815 \\
 \hline
 6520 \\
 6642.25 \\
 81.5 \\
 \hline
 3321125 \\
 664225 \\
 \hline
 5313800 \\
 541343.375 \text{ cubic inches}
 \end{array}$$

3. Remembering that there are 1,728 cubic inches in a cubic foot, divide by 1,728.

$$\begin{array}{r}
 313.277 + \text{cu. ft.} \\
 1728 \overline{) 541343.375} \\
 \underline{5184} \\
 2294 \\
 \underline{1728} \\
 5663 \\
 \underline{5184} \\
 4793 \\
 3456 \\
 \underline{13377} \\
 12096 \\
 \underline{12815} \\
 12096 \\
 \underline{} \\
 719
 \end{array}$$

4. Remembering that there are 231 cubic inches in a gallon, divide this into the number of cubic inches in the tank.

$$\begin{array}{r}
 2.07 \\
 2.07 \\
 \hline
 1449 \\
 414 \\
 \hline
 4.2849 \\
 2.07 \\
 \hline
 299943 \\
 85698 \\
 \hline
 8.869743 \text{ cubic meters}
 \end{array}$$

2. Since there are 1,000 liters in a cubic meter the number of liters in the tank is determined by moving the decimal point three places to the right- 8,869.743 liters.
3. A liter of water weighs one kilogram; so, the water weighs 8,869.743 kilograms.

$$\begin{array}{r}
 2343.477 + \text{Gallons} \\
 231 \overline{) 541343.375} \\
 \underline{462} \\
 793 \\
 \underline{693} \\
 1004 \\
 \underline{924} \\
 803 \\
 \underline{693} \\
 1103 \\
 \underline{924} \\
 1797 \\
 \underline{1617} \\
 1805 \\
 \underline{1617} \\
 188
 \end{array}$$

5. Remembering that a cubic foot of water weighs 62 1/2 pounds, multiply the number of cubic feet in the tank by 62.5.

$$\begin{array}{r}
 313.277 + \text{Cubic feet} \\
 62.5 \\
 \hline
 1566385 \\
 626554 \\
 1879662 \\
 \hline
 19579.8125 \text{ pounds}
 \end{array}$$

Using the metric system, the problem involves 39 digits, and to do multiplication and division the student needs only to move a decimal point. Using the customary system the problem involves 249 digits in five lengthy multiplication and division steps and the increased possibility of error. Moreover, the answer when using the customary system is only approximate since there is an inaccuracy of about eleven pounds due to dropping the clumsy fraction. The above problem was an easy one. It would be more complex if the dimensions of the tank were 3'7 1/8" x 1'2 3/4" x 4'9 5/16".

Calculating is made simpler when using the metric system. Suppose a student wanted to know how many five ounce portions there are in a can containing one pound six ounces, when using the customary system. She or he must first convert the weight to 22 ounces and then divide by five. To get the number of 110 gram portions in a 600 gram can, using the metric system, she or he need merely divide 60 by 11.

It is also easier to compare prices when using the metric system. Suppose a student wanted to make a rough comparison between a "large" size box containing one pound six ounces selling for 58 cents and a "giant economy" size containing two pound two ounces selling for 98 cents. She or he must first transpose both amounts to ounces and then divide 58 cents by 22 ounces and 98 cents by 34 ounces to learn that the giant economy size is a fake bargain. However, if a student uses the metric system and compares the prices of a 700 gram box at 58 cents and a 1040 gram box at 98 cents she or he merely has to divide 58 cents by seven and 98 cents by ten (plus) to get the relative cost per 100 gram and learn that the smaller box is the better buy.

It is easier to compute length in millimeters when using the metric system than in feet, inches and fractions of inches. A student, for example, may want to know the

amount of lumber required to build something having units of 2'10 1/2", 7'7 13/16", 5'6", and 3'9 5/8". To use the customary system she or he must reduce all of the fractional inches to sixteenths and then perform this calculation:

2 feet	10 inches	8 sixteenths
7 feet	7 inches	13 sixteenths
5 feet	6 inches	
<u>3 feet</u>	<u>9 inches</u>	<u>10 sixteenths</u>
17 feet	32 inches	31 sixteenths

She or he must divide 31 by 16 and carry over to the inch column and divide 33 by 12 and carry over to the foot column to find out that she or he needs 19'9 15/16" of lumber.

This compares with the student who is building the same thing working in the metric system with dimensions expressed in millimeters. She or he merely adds a column of figures and moves a decimal point, thus:

$$\begin{array}{r}
 876 \text{ mm} \\
 2,332 \text{ mm} \\
 1,676 \text{ mm} \\
 1,159 \text{ mm} \\
 \hline
 6,043 \text{ mm} \text{ or } 6.043 \text{ m of lumber}
 \end{array}$$

The United States is the only major nation which has not converted to the metric system. International trade and instant communications made the world-wide adoption of standard units of measurement a necessity. Businessmen in the United States buy billions of dollars worth of goods from other countries. Other countries buy goods from the United

States in return. To our disadvantage many of the products manufactured in the United States are engineered in "customary" units of measure (inches, pounds, etc.) whereas foreign customers use items engineered in metric units (kilograms, centimeters, etc.). The problem that exists with such an arrangement can be easily understood.

For example, a foreign customer owns a car manufactured in the United States and has to replace a bolt. The only bolts available in stores where the customer lives have thread spacings in millimeters. They won't work as replacements for United States manufactured bolts which have so many threads per inch.

Foreign customers will be reluctant to purchase United States products when confronted with problems in replacing parts or making repairs. If the United States is to improve its balance of trade by increasing its sales of consumer items and parts then the goods sold must be compatible with those currently in use in the countries we trade with. To assure compatibility, buyer and seller should use the same measurement system.

In summation, the metric system is simpler to use and it is superior to the customary system. Because it is simpler students are less likely to make mathematical errors. The students at the Greenock and Mount Vernon Schools needed to know the metric system.

RESEARCH TO DEVELOP STRATEGY

During June 22 to 25, 1976, the writer attended a workshop titled CSE Evaluation Workshop I, sponsored by the Pennsylvania Department of Education. The Center for Study of Evaluation at the University of California at Los Angeles developed the evaluation program. Five evaluation phases provided the framework for the decision-making process: Needs assessment, program planning, implementation evaluation, progress evaluation, and outcome evaluation. The two major goals of the program were to develop participant understanding of the kinds of information an evaluation can provide for educational decision making, and understanding of the general procedures and problems involved in selecting, collecting, analyzing and reporting that information.

While attending the CSE Evaluation Workshop I, the writer considered various program planning tools and procedures. The writer first considered employing the services of a consultant who could provide high level expertise in the field of metrication. Consideration was also given to conducting a Delphi study, which is a consensus among a panel of experts who interact by mail through an intermediary.

Conducting a Delphi study would also provide expert opinions and have an added advantage of providing a feasible way to gather information in a short time, without

the logistics problems inherent in organizing a meeting. Both of these program planning methods were rejected. Since the Title IV-B allocation for metrication for the Greenock and Mount Vernon Elementary Schools for the school year 1976-77 was \$500.00 the writer could ill afford to hire consultants.

Developing a PERT chart to describe how the program would operate was also considered. Essential steps in the program would be stated and developed graphically; the flow and interrelationships of steps and accompanying decisions would be pictured. While the PERT chart would be an excellent tool for monitoring the progress of the program it does not incorporate many important aspects of program planning such as costs and potential success in meeting objectives. The writer, therefore, discarded this planning procedure.

The most desirable tool for planning and implementing the metric program, given the constraint of cost, was the planning committee. This multi-person approach to planning ensured that a number of viewpoints would be considered in the development process.

A planning committee was convened in July, 1976 to determine the need for and general structure of the program. The planning committee resolved that sequential and prescribed objectives for the teaching of metric skills at each grade level be developed and that the students' acquisition of these skills be measured at the end of the 1976-77 school year.

The writer recognized that the teachers involved in the program would probably need training, especially since they may have only been taught the customary system. The Elizabeth Forward School District's contract with the Elizabeth Forward Educational Association permitted nine faculty meetings per year to be conducted at the Greenock and Mount Vernon Elementary Schools. These faculty meetings were utilized and provided the time necessary for explaining the program to the teachers.

During the 1976-77 school year a new science program was being installed, in addition to the phasing in of a new reading program. The writer considered the many new demands on the teachers for the 1976-77 school year and thought it most practical to utilize the matrix sampling technique when collecting data for the formative and summative evaluations. Since the writer was primarily concerned with group rather than individual scores on all students in the program the matrix sampling technique of data collection provided the

writer with this information at a great savings of teachers' time.

The metric objectives and related activities were selected for each grade level based upon Jean Piaget's findings. Piaget states that:

Measurement is a synthesis of the operations of subdivision into parts and of substitution of a part upon others. The ability to measure develops later than the number concept because it is more difficult to divide a continuous whole, such as an object being measured, into interchangeable subunits than it is to count a set of objects that are separate and discrete from each other, such as leads or blocks.²

Piaget believes that one cannot tell children how to measure; they should be provided with appropriate materials and be allowed to experiment and to try to solve measurement problems for themselves. The necessary concepts will develop when she or he is allowed to experiment with objects used in measurement.³

Gary Bitter points out that:

Anyone providing measurement-learning experiences needs to keep two important ideas in mind: (1) measurement is by nature a hands-on activity in which children need to get personally involved, (2) many concrete, exploratory activities should

²Jean Piaget, "How Children Form Mathematical Concepts," Scientific American (November, 1953), p. 78.

³Ibid.

precede measurement using standardized tools or measurement algorithms.⁴

The emphasis in the primary grades was on exploring metric measures. Students were involved in simple problem-solving situations without utilizing standard units.

The emphasis in the intermediate grades, however, was on discovering metric measures. Measurement concepts were refined, vocabulary extended, and students were taught to use measuring instruments with increasing skill.

⁴Gary G. Bitter, Activities Handbook for Teaching the Metric System (Boston, 1976), p. 16.

OBJECTIVES OF THE PRACTICUM

The primary goal for the practicum was to have students in grades one through six achieve at least 80 percent mastery of the specified metric performance objectives by the end of the school year 1976-77. As a means for measuring the success of the program and for purposes of guiding the instructional process performance objectives were used. Grade levels one, two and three were each assigned five performance objectives. Grade levels four, five and six were each assigned ten performance objectives. A total of 45 performance objectives were used for grades one through six. The specific objectives used for each grade level are listed below:

<u>Metric Measurements</u>	<u>Objective</u>
	<u>Grade Level One:</u>
Linear:	1.1 The student will be able to compare lengths of measure.
	1.2 The students will be able to recognize the constancy of length even though units change.
	1.3 The student will be able to apply correct measuring procedure using nonstandard units.
	1.4 The student will be able to find lengths equal to a given length.
Mass:	1.5 The student will be able to compare the mass of objects and become familiar with the terminology "heavier than," "lighter than."

Metric MeasurementsObjectiveGrade Level Two:

Volume and Capacity:

- 1.6 The student will be able to describe an accurate estimate of a cubic meter.

Linear:

- 1.7 The student will be able to measure using standard (centimeter cubes or strips) and nonstandard units.

Mass:

- 1.9 The student will be able to demonstrate recognition of the noncorrelation of mass and volume by ranking objects according to their mass, not their size.
- 1.10 The student will demonstrate the ability to use a balance scale.

Grade Level Three:

Linear:

- 1.11 The student will use a standard unit (meter) for measuring distances.
- 1.12 The student will learn to use a metric ruler to measure in centimeter.

Area and Perimeter:

- 1.13 The student will demonstrate that the perimeter remains constant even though the shape of a figure changes.

Volume and Capacity:

- 1.14 The student will be able to determine the capacity of a given container using standard measuring tools.

Mass:

- 1.15 The student will be able to accurately assess whether an object is heavier or lighter than a predetermined mass.

Metric MeasurementsObjectiveGrade Level Four:

Linear:

- 1.16 The student will be able to measure in millimeters.
- 1.17 The student will be able to calculate the area of a rectangular surface.

Area and Perimeter:

- 1.18 The student will be able to predict the number of units needed to cover a certain area.
- 1.19 The student will be able to calculate the area of a rectangular surface.
- 1.20 The student will be able to use a trundle wheel or metric tape measure to measure long distances.

Volume and Capacity:

- 1.21 The student will be able to predict the number of units needed to make a square into a cube.
- 1.22 The student will develop a "frame of reference" for a liter.

Mass:

- 1.23 The students will be able to determine the minimum number of mass pieces that need to be constructed to determine the mass of any object having a mass from 1 to 100 g.

Temperature

- 1.24 The student will be able to list two factors that influence the boiling point of water.
- 1.25 The student will be able to name one factor that will lower the freezing point of water.

Metric MeasurementsObjectiveGrade Level Five:

Linear:

- 1.26 The student will be able to determine the length of objects by using appropriate metric measures.

Area and Perimeter:

- 1.27 The student will be able to compute the area of various rectangular shapes.
- 1.28 The student will be able to measure large areas.
- 1.29 The student will be able to determine the number of small unit areas in a larger area.
- 1.30 The student will be able to predict the area of squares by knowing the measurement of one side of the square.

Volume and Capacity:

- 1.31 The student will be able to accurately find the capacity of containers in milliliters.
- 1.32 The student will be able to accurately find the volume of a box using metric units.

Mass:

- 1.33 The student will be able to accurately measure mass.
- 1.34 The student will be able to state the relationship that exists between the mass of a particular amount of water and the volume it occupies.

Metric MeasurementsObjective

Temperature:

- 1.35 The student will be able to name the Celsius temperature for four common temperatures:

1. Boiling water
2. Freezing water
3. Room temperature
4. Body temperature

Grade Level Six:

Linear:

- 1.36 The student will be able to make a metric scale drawing.

Area and Perimeter:

- 1.37 The student will be able to accurately determine the surface area of a rectangular solid.

- 1.38 The student will be able to show that perimeter measurements are independent of area measurements.

- 1.39 The student will be able to measure area and linear distance accurately.

Volume and Capacity:

- 1.40 The student will be able to accurately find the capacity of a container.

- 1.41 The student will be able to accurately give volume measures as the dimensions are doubled and tripled.

- 1.42 The student will be able to state a metric relationship between mass and volume.

- 1.43 The student will be able to measure and compute the volume of a rectangular solid and a cylinder.

Metric MeasurementsObjective

Mass:

- 1.44 The student will be able to find the mass of objects accurately and calculate using metric measures.

Temperatures:

- 1.45 The student will be able to relate Celsius temperatures to everyday situations.

PRACTICUM DESIGN AND IMPLEMENTATION

The Elizabeth Forward School District, like most other neighboring school districts, was ill-prepared for teaching metrication. Up until the implementation of the practicum there was virtually no teaching of metrication taking place in the Elizabeth Forward elementary schools.

A planning committee composed of the Director of Elementary Education and the Director of Secondary Education and all of the principals in the Elizabeth Forward School District met in July, 1976, to discuss the primary needs of the school district and the initiating of programs to meet those needs. During the meeting it was recognized that the current mathematics program for elementary students was deficient and in need of updating in the area of metrication. The committee also acknowledged that no mathematics curriculum guide existed and that sequential and prescribed objectives for the teaching of metric skills at each grade level were necessary. At that time a determination was made by the planning committee to develop and institute a program to ensure the teaching of metrication for the 1976-77 school year.

During the school year 1976-77 there were 559 students attending the Greenock and Mount Vernon Elementary Schools in grades one through six. The majority of the student population, from both schools, came from upper-middle class

homes, socio-economically speaking, and resided in the suburbs near Pittsburgh, Pennsylvania. A total of 19 classroom teachers, ranging from grades one through six, participated in the program. The writer was the principal of both elementary schools.

As noted in the preceding chapter performance objectives were used in grade levels one through six. Each performance objective was keyed to a metric activity (See Appendix, Chapter E, page 59). Teachers had the option to select any metric activities available provided the activities conformed to the prescribed performance objectives. The Metric Labs purchased from Pennsylvania Educational Aids, Inc. provided the teachers with additional metric activities.

Each performance objective was also keyed to a criterion-referenced test item (See Appendix, Chapter F, page 145). Each test item was given a weighted value of 20 percent. The following Program Design Chart clarifies the aforementioned parts of the practicum.

PROGRAM DESIGN

Grades at Mount Vernon and Greenock Elementary

	1	2	3	4	5	6	Total
Number of Performance Objectives	5	5	5	10	10	10	45
Number of Activities Keyed to Performance Objectives	5	5	5	10	10	10	45
Number of Post-Test Items Keyed to Performance Objectives	5	5	5	10	10	10	45
Percentages for Weighted Value Per Test Item	20	20	20	20	20	20	--
Number of Classroom Teachers Involved in Program	3	3	3	3	3	4	19
Number of Students Involved in Program	96	96	88	87	86	106	559

During the month of October, 1976, the writer held two faculty meetings at the Greenock and Mount Vernon Elementary Schools. Teachers were informed about the goal and objectives of the program. Each teacher received a booklet composed of the performance objectives and related, suggested activities to be taught at each grade level. Mr. John Cochenour, a sales representative from Pennsylvania Educational Aids, Inc., was on hand to help demonstrate the use of the manipulative metric equipment and materials which were used for the program.

In November, 1976, the writer conducted two more faculty meetings at the Greenock and Mount Vernon Elementary Schools. The teachers at the Greenock School requested further clarification about their responsibilities in order to successfully complete the program. The writer obliged by reviewing the design of the program and the teachers' role in the program.

The teachers at the Mount Vernon School wanted to know more about the advantages of the metric system as opposed to the customary system. The writer answered their questions and solved several mathematical problems using both systems so the teachers could more clearly know the advantages of the metric system.

Also in November, 1976, each teacher in the program received a Teacher Formative Evaluation Form to complete. As shown in the following tally report, all 19 teachers stated they had access to metric equipment and materials.

Sixteen of 19 teachers stated they were teaching the metric skills. The writer met with the three teachers who were not teaching the metric skills and found that they did not know enough about metrication to feel competent in teaching it. These three teachers also stated on the Teacher Evaluation Form that most of their students were not learning most of the metric skills assigned to their grade level. These same three teachers also stated that they needed help in order to present the metric activities to their students. The writer conducted demonstration lessons for the benefit of these three teachers, including two other teachers who also requested assistance.

TEACHER FORMATIVE EVALUATION

TALLY REPORT

	<u>Mount Vernon</u>		<u>Greenock</u>		<u>Total</u>	
	<u>Yes</u>	<u>No</u>	<u>Yes</u>	<u>No</u>	<u>Yes</u>	<u>No</u>
1. Do you now have access to equipment and materials for teaching the metric skills assigned to your grade level?	6	0	13	0	19	0
2. Are you teaching the metric skills?	5	1	11	2	16	3
3. Are most of the students learning most of the metric skills assigned to your grade level?	5	1	10	2	16	3
4. Do you understand the metric system enough to teach the metric skills that are assigned to your class?	6	0	10	3	16	3
5. Do you need help in order to present the metric activities to the children at your grade level?	2	4	3	9	5	13

During the two faculty meetings in December, 1976, Mr. Frank Stoner, the Media Specialist for the Elizabeth Forward School District, talked to the faculty members at the Greenock and Mount Vernon Elementary Schools on the correct procedure for procuring metric equipment and materials from the school district's Audio-Visual Department. He also reviewed with the faculty the role of the principal's aide as it pertained to procuring metric materials. He exhibited during the faculty meeting metric materials which were readily available to teachers upon request.

In January, 1977, during the two faculty meetings, the writer conducted experiments using Celsius thermometers for the benefit of the teachers at Greenock and Mount Vernon Schools. Teachers practiced reading the thermometers as the experiments were being conducted.

In February, 1977, at both the Greenock Elementary School and Mount Vernon Elementary School faculty meetings the writer conducted activity number 24, which dealt with factors that influence the boiling point of water, for the benefit of all teachers. All teachers were able to read the temperature changes on the Celsius thermometer and to determine the metric temperature of boiling water. The writer also explained to them how to randomly select students for the administering of the criterion-referenced test.

In February, 1977, students who attended the Greenock and Mount Vernon Schools (grades one through six) were

administered the criterion-referenced test in order to conduct a formative evaluation. The matrix sampling technique was used. As shown on the following Procedure for Administration of Formative and Summative Evaluation Chart a total of 225 students were tested.

A total of 25 students were tested in each of the primary grades-one, two and three. A total of 50 students were tested in each of the intermediate grades-four, five and six. Twice as many students at the Greenock School were given the criterion-referenced test since the enrollment at the Greenock School was approximately double that of the Mount Vernon School.

In order to include a larger sampling of students no student was administered more than one criterion-referenced test item. A total of five students were tested to measure how well each performance objective had been achieved.

PROCEDURE FOR ADMINISTRATION OF
FORMATIVE AND SUMMATIVE EVALUATION
ADMINISTERED IN FEBRUARY AND MAY, 1977

Grade Level	Number of Students Tested	Number of Students Per Test Item	Number of Test Items Per Student	Number of Teachers Adminis- tering Test	Number of Performance Objectives Tested at Each School			
					Mount Vernon		Greenock	
1	25	5	1	3	1.1		1.2 1.3	1.4 1.5
2	25	5	1	3	1.6		1.7 1.8	1.9 1.10
3	25	5	1	3	1.11		1.12 1.13	1.14 1.15
4	50	5	1	3	1.16 1.17	1.18 1.19	1.20 1.21 1.22	1.23 1.24 1.25
5	50	5	1	3	1.26 1.27	1.28 1.29	1.30 1.31 1.32	1.33 1.34 1.35
6	50	5	1	4	1.36 1.37	1.38 1.39	1.40 1.41 1.42	1.43 1.44 1.45
Total	225	--	--	19	15		30	

As shown by the data that follow, grades one, two, and four had already achieved the 80 percent mastery level by February, 1977, with grades three, five and six making substantial progress. The percentage correct for each performance objective was reported to the teachers so they could determine which skills students to date had not mastered at the 80 percent level or above. The writer felt, based upon the data presented, that the program was progressing well.

FORMATIVE EVALUATION

GRADE 1

(Greenock and Mount Vernon Schools)

<u>Performance Objectives</u>	<u>Responses to Criterion-Referenced Test Items</u>		<u>Total</u>	<u>Percentage Correct*</u>
	<u>Number Incorrect</u>	<u>Number Correct</u>		
1.1	0	5	5	100%
1.2	1	4	5	80%
1.3	1	4	5	80%
1.4	0	5	5	100%
1.5	0	5	5	100%
Total	2	23	25	92%**

*Weighted value per test item is 20%.

**Average percent.

FORMATIVE EVALUATION

GRADE 2

(Greenock and Mount Vernon Schools)

<u>Performance Objectives</u>	<u>Responses to Criterion-Referenced Test Items</u>		<u>Total</u>	<u>Percentage Correct*</u>
	<u>Number Incorrect</u>	<u>Number Correct</u>		
1.6	0	5	5	100%
1.7	0	5	5	100%
1.8	0	5	5	100%
1.9	0	5	5	100%
1.10	3	2	5	40%
Total	3	22	25	88%**

*Weighted value per test item is 20%.

**Average percent.

FORMATIVE EVALUATION
GRADE 3
(Greenock and Mount Vernon Schools)

Performance Objectives	Responses to Criterion-Referenced Test Items		Total	Percentage Correct*
	Number Incorrect	Number Correct		
1.11	4	1	5	20%
1.12	0	5	5	100%
1.13	3	2	5	40%
1.14	4	1	5	20%
1.15	0	5	5	100%
Total	11	14	25	56%**

*Weighted value per test item is 20%.
**Average percent.

FORMATIVE EVALUATION
GRADE 4
(Greenock and Mount Vernon Schools)

Performance Objectives	Responses to Criterion-Referenced Test Items		Total	Percentage Correct*
	Number Incorrect	Number Correct		
1.16	0	5	5	100%
1.17	3	2	5	40%
1.18	1	4	5	80%
1.19	1	4	5	80%
1.20	0	5	5	100%
1.21	0	5	5	100%
1.22	0	5	5	100%
1.23	0	5	5	100%
1.24	0	5	5	100%
1.25	2	3	5	60%
Total	7	43	50	86%**

*Weighted value per test item is 20%.
**Average percent.

FORMATIVE EVALUATION
GRADE 5
(Greenock and Mount Vernon Schools)

Performance Objectives	Responses to Criterion-Referenced Test Items		Total	Percentage Correct*
	Number Incorrect	Number Correct		
1.26	0	5	5	100%
1.27	1	4	5	80%
1.28	4	1	5	20%
1.29	4	1	5	20%
1.30	0	5	5	100%
1.31	3	2	5	40%
1.32	0	5	5	100%
1.33	1	4	5	80%
1.34	0	5	5	100%
1.35	0	5	5	100%
Total	13	37	50	74%**

*Weighted value per test item is 20%.

**Average percent.

FORMATIVE EVALUATION
GRADE 6
(Greenock and Mount Vernon Schools)

Performance Objectives	Responses to Criterion-Referenced Test Items		Total	Percentage Correct*
	Number Incorrect	Number Correct		
1.36	1	4	5	80%
1.37	5	0	5	0%
1.38	0	5	5	100%
1.39	1	4	5	80%
1.40	1	4	5	80%
1.41	1	4	5	80%
1.42	1	4	5	80%
1.43	5	0	5	0%
1.44	1	4	5	80%
1.45	0	5	5	100%
Total	16	34	50	68%**

*Weighted value per test item is 20%.

**Average percent.

Again in March of 1977, the teachers were given a Teacher Formative Evaluation Form to complete. As shown on the Teacher Formative Evaluation Tally Report, all teachers felt that they had sufficient access to metric materials and equipment. They were teaching metrication to their students. All of the teachers also felt that most of the students were learning metric skills and that the metric objectives prescribed for their grade level were being mastered.

While all of the teachers felt that they understood the metric objectives that were assigned to their grade level, only one expressed some uncertainty in being able to teach the metric objectives without assistance. The writer conducted another demonstration lesson for that particular teacher and reviewed the basic principles of metrication with her.

TEACHER FORMATIVE EVALUATION

TALLY REPORT

	Mount Vernon		Greenock		Total	
	<u>Yes</u>	<u>No</u>	<u>Yes</u>	<u>No</u>	<u>Yes</u>	<u>No</u>
1. Do you now have access to equipment and materials for teaching the metric skills assigned to your grade level?	6	0	13	0	19	0
2. Are you teaching the metric skills?						
3. Are most of the students learning most of the metric skills assigned to your grade level?	6	0	13	0	19	0
4. Do you understand the metric system enough to teach the metric skills that are assigned to your class?	6	0	13	0	19	0
5. Do you need help in order to present the metric activities to the children at your grade level?	1	5	0	13	1	18
6. Please make any suggestions or comments about the metric materials and skills being taught.						

In April, 1977, two faculty meetings were held, one at the Mount Vernon School and the other at the Greenock School. During these meetings the writer reviewed with the teachers how to administer the criterion-referenced post-tests to their randomly selected students. At the Greenock School faculty meeting the writer also explained to all teachers how to use the micrometer which was calibrated in millimeters.

In May of 1977 a criterion-referenced test was again administered to a random sampling of students, as shown on the Procedure for Administration of Formative and Summative Evaluation Chart. The results, as indicated by the following tables, have shown that the students at each grade level (one through six) have mastered 80 percent of the performance objectives. Overall, a composite score for the six grade levels indicated that students have mastered the performance objectives at the 93.33 percent level.

SUMMATIVE EVALUATION

GRADE 1

(Greenock and Mount Vernon Schools)

<u>Performance Objectives</u>	<u>Responses to Criterion-Referenced Test Items</u>		<u>Total</u>	<u>Percentage Correct*</u>
	<u>Number Incorrect</u>	<u>Number Correct</u>		
1.1	0	5	5	100%
1.2	1	4	5	80%
1.3	0	5	5	100%
1.4	0	5	5	100%
1.5	0	5	5	100%
Total	1	24	25	96%**

*Weighted value per test item is 20%.

**Average percent.

SUMMATIVE EVALUATION

GRADE 2

(Greenock and Mount Vernon Schools)

<u>Performance Objectives</u>	<u>Responses to Criterion-Referenced Test Items</u>			<u>Percentage Correct*</u>
	<u>Number Incorrect</u>	<u>Number Correct</u>		
1.6	1	4	5	80%
1.7	0	5	5	100%
1.8	0	5	5	100%
1.9	0	5	5	100%
1.10	0	5	5	100%
Total				96%**

*Weighted value per test item is 20%.

**Average percent.

SUMMATIVE EVALUATION
GRADE 3
(Greenock and Mount Vernon Schools)

<u>Performance Objectives</u>	<u>Responses to Criterion-Referenced Test Items</u>		<u>Total</u>	<u>Percentage Correct*</u>
	<u>Number Incorrect</u>	<u>Number Correct</u>		
1.11	1	4	5	80%
1.12	0	5	5	100%
1.13	0	5	5	100%
1.14	0	5	5	100%
1.15	0	5	5	100%
Total	1	24	25	96%**

*Weighted value per test item is 20%.

**Average percent.

SUMMATIVE EVALUATION
GRADE 4
(Greenock and Mount Vernon Schools)

<u>Performance Objectives</u>	<u>Responses to Criterion-Referenced Test Items</u>		<u>Total</u>	<u>Percentage Correct*</u>
	<u>Number Incorrect</u>	<u>Number Correct</u>		
1.16	0	5	5	100%
1.17	0	5	5	100%
1.18	0	5	5	100%
1.19	0	5	5	100%
1.20	1	4	5	80%
1.21	0	5	5	100%
1.22	0	5	5	100%
1.23	0	5	5	100%
1.24	0	5	5	100%
1.25	1	4	5	80%
Total	2	48	50	96%**

*Weighted value per test item is 20%.

**Average percent.

SUMMATIVE EVALUATION
GRADE 5
(Greenock and Mount Vernon Schools)

Performance Objectives	Responses to Criterion-Referenced Test Items		Total	Percentage Correct*
	Number Incorrect	Number Correct		
1.26	0	5	5	100%
1.27	0	5	5	100%
1.28	1	4	5	80%
1.29	2	3	5	60%
1.30	0	5	5	100%
1.31	0	5	5	100%
1.32	1	4	5	80%
1.33	0	5	5	100%
1.34	0	5	5	100%
1.35	0	5	5	100%
Total	4	46	50	92%**

*Weighted value per test item is 20%.

**Average percent.

SUMMATIVE EVALUATION
GRADE 6
(Greenock and Mount Vernon Schools)

SUMMATIVE EVALUATION
GRADE 6
(Greenock and Mount Vernon Schools)

Performance Objectives	Responses to Criterion-Referenced Test Items		Total	Percentage Correct*
	Number Incorrect	Number Correct		
1.36	0	5	5	100%
1.37	1	4	5	80%
1.38	0	5	5	100%
1.39	2	3	5	60%
1.40	1	4	5	80%
1.41	0	5	5	100%
1.42	3	2	5	40%
1.43	1	4	5	80%
1.44	0	5	5	100%
1.45	0	5	5	100%
Total	8	42	50	84%**

*Weighted value per test item is 20%.

**Average percent.

SUMMATIVE EVALUATION
COMPOSITE SCORE
FOR
GRADES ONE THROUGH SIX

<u>Grade</u>	<u>Average Percent</u>	<u>Objective Achieved</u>
1	96%	Yes
2	96%	Yes
3	96%	Yes
4	96%	Yes
5	92%	Yes
6	84%	Yes
	93.33%	

RECOMMENDATIONS AND CONCLUSIONS

The writer believes the implementation of the practicum increased significantly the level of consciousness of students and teachers regarding metrication. Teachers were accountable for teaching metrication to their students. As the students progress through the grade levels they should gain mastery over an increasing number of metric skills. Teachers are familiar with the metric equipment and materials that were made available while the program was being introduced.

Employing an external evaluator for the future monitoring of the program is advantageous in one respect. While there is no perfectly unbiased evaluator, gains in objectivity can be made by employing an external evaluator. However, the teachers and the writer are more familiar than anyone else with the program and therefore internal evaluators do have a distinct advantage. Moreover, the use of external evaluators is likely to be threatening to staff members and may lead to considerable difficulty in getting required information.

The writer recommends that any testing of students' acquisition of metric skills include a greater person sampling in order to insure the reliability of the test results. To more accurately measure the effect of the treatment on the students all students in grades one through six should be tested periodically.

The writer also suggests that any future monitoring of the program include a one group pretest-posttest design rather than the one shot case study that was conducted. The one group pretest-posttest design will permit the evaluator to ascertain the learner's entry behavior prior to his interaction with the treatment. The one shot case study was an appropriate treatment to use when introducing metrication since it was assumed the students had virtually no metric skills prior to the introduction of the program.

INSTITUTIONALIZATION OF OUTCOME

Establishing the state regulations mandated change at the state level. But it wasn't until this project was developed and implemented that metrication was actually taught and students began to master metric skills. The prescribed metric performance objectives are now included as part of the mathematics program at the Mount Vernon and Greenock Elementary Schools.

DISSEMINATION AND FURTHER APPLICATION OF THE PRACTICUM

The consulting firm of Alexander and Alexander Associates was hired by the Elizabeth Forward School District to direct the district's projected five-year educational plan, as required by the Pennsylvania Department of Education. One of the objectives established in the above-mentioned plan is to develop a mathematics curriculum guide. A copy of this practicum report has been given to the mathematics curriculum committee. They will meet during the Summer of 1977 to develop the mathematics guide and will include in it the objectives for teaching metric skills developed for the project. The report will be useful to the committee since it establishes a base line when identifying specific metric skills to be taught successfully at each grade level, taking into consideration the students' previous acquisition of mathematical skills.

In June, 1977, the South Park Cluster of participants in Nova University's National Ed.D. Program for Educational Leaders received a copy of this practicum report in which the writer explained in detail the various components of the project. In addition, John Cochenour, a sales representative for Pennsylvania Educational Aids, lectured on the project to college professors and students at Waynesburg College, Waynesburg, Pennsylvania. The project was also explained to

faculty members at the William Penn, Central, Elizabeth and Yough Elementary Schools as well. These above-mentioned elementary schools are part of the Elizabeth Forward School District.

APPENDIX A

MATERIAL AND EQUIPMENT UTILIZED DURING PRACTICUM

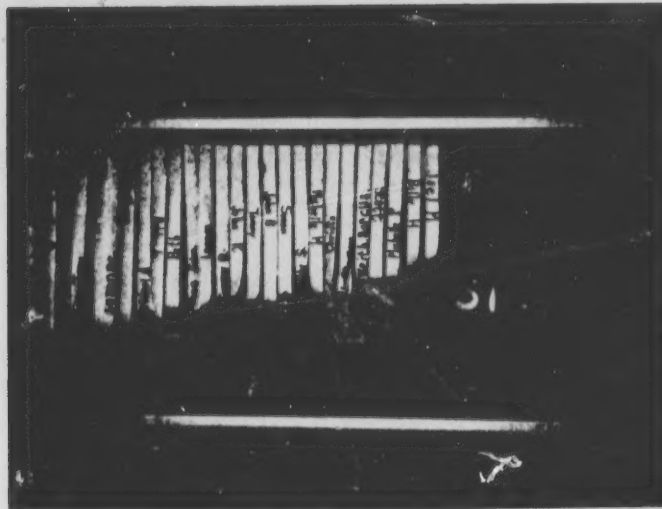
The following materials and equipment were purchased both from local monies and from E.S.E.A.

Title IV-B funds:

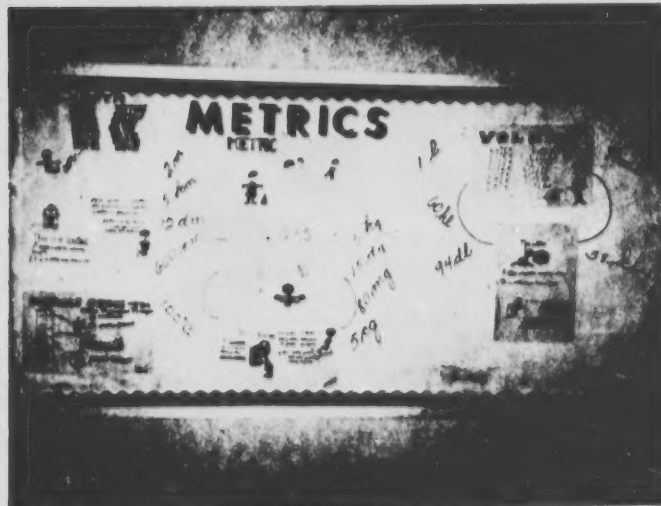
<u>Number</u>	<u>Item</u>
2	The Metric Lab (Comprehensive kit)
2	Metric Stacking Masses and Guide
10	Metric Balance
130	Metric Height Measure
200	SI Rulers
210	Intermediate Rulers
2	Micrometers
10	Immersion Thermometers
4 sets	Economy Beakers
2	Metric Personal Scale
2	Litre Pan Balance
23	The Everyday Guide to the Metric System
2	Trundle Wheel
10	Celsius Thermometers and Guide
4,000	Centimeter Cubes

APPENDIX B

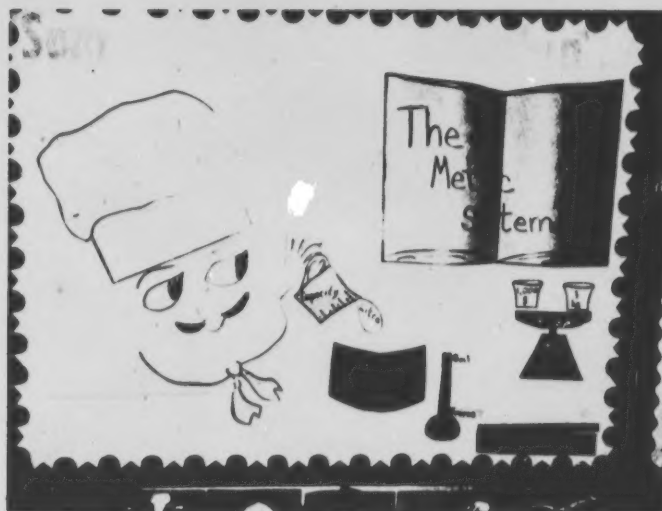
PHOTOGRAPHS OF METRIC ACTIVITIES



The above bulletin board display was correlated to the Number 1.1 Performance Objective. Students measured their steps and compared them to their classmates.



The bulletin board displayed above is correlated to the Performance Objectives at the fifth grade level. Students made posters pertaining to volume, temperature, etc.



The bulletin board displayed above is correlated to Performance Objective Number 1.7.



At the sixth grade level students constructed displays correlated to their assigned performance objectives.



In this photograph second grade students are measuring their height in centimeters. This activity is related to Performance Objective Number 1.7.



A fifth grade student is using the balance scale to determine mass. This activity is related to Performance Objective Number 1.33.



A sixth grade student is using the trundle wheel. This activity is related to Performance Objective Number 1.39.



In this photograph a second grade student is determining his mass using a metric scale. This activity is related to Performance Objective Number 1.8.

APPENDIX C

LOG OF EVENTS

<u>Date</u>	<u>School</u>	<u>Event</u>
10/4/76 to 10/6/76	Greenock and Mount Vernon	The writer held a faculty meeting with all the teachers from first grade through sixth grade for the purpose of explaining the "Improvement in Teaching Metrication by Means of Performance Objectives Program." Each teacher received a booklet composed of the performance objectives and related suggested activities to be taught for each grade level. Mr. John Cochenour, a sales representative from Pennsylvania Educational Aids, Inc., was on hand to help demonstrate the use of the manipulative metric equipment and materials which were to be used for the program.
11/1/76	Greenock	The writer held a faculty meeting with the teachers. They wanted further clarification on the program. We therefore discussed it in greater detail, talking about the specific objectives and activities to be taught at each grade level.
11/9/76	Mount Vernon	During this faculty meeting the writer explained how and why the metric system is superior to the English system of measurement.
11/30/76		The Teacher Formative Evaluation Form is distributed to the faculties.

APPENDIX C (Continued)

LOG OF EVENTS

<u>Date</u>	<u>School</u>	<u>Event</u>
12/1/76	Elizabeth	Upon request I talked at a faculty meeting about the program to the teachers. I also demonstrated some of the metric experiments and provided them with supplies so they could do the experiments with their students if they so chose.
12/6/76	Greenock	During this faculty meeting Mr. Stoner, our media specialist, explained with the faculty how they are to procure metric materials from the Audio-Visual Department. The role of the principal's aide, in reference to procuring metric supplies, and the completing of forms was discussed.
12/8/76	William Penn	Upon request from the building principal, I explained the program to the faculty and demonstrated the use of metric equipment. John Cochenour was also present to show the metric materials that Pennsylvania Educational Aids, Inc. produces.
12/14/76	Mount Vernon	At this faculty meeting Frank Stoner, the media specialist, explained to the staff how to procure audio-visual metric equipment and materials. The role of the principal's aide, in reference to procuring metric supplies, was also discussed.

APPENDIX C (Continued)

LOG OF EVENTS

<u>Date</u>	<u>School</u>	<u>Event</u>
12/14/76	Central	During this faculty meeting I introduced the faculty to the program. I also demonstrated how to do several metric activities and John Cochenour, sales representative, was also on hand to assist with the demonstration.
1/10/77	Greenock	I demonstrated to the faculty, during the faculty meeting, experiments related to the Celsius thermometer, and also answered questions they had about the program.
1/11/77	Mount Vernon	We, the faculty and I, talked about how the program was progressing. I also demonstrated experiments related to the Celsius thermometer.
1/18/77 to 1/21/77 and 1/31/77 to 2/2/77		Schools were closed by Governor Shapp's decree and the emergency conditions created by the energy crisis.
1/12/77	Yough	I was also invited to speak before the Yough Elementary School faculty members to present the metric program. John Cochenour and I demonstrated the use of metric materials and equipment while discussing the teaching of specific metric objectives with the teachers.

APPENDIX C (Continued)

LOG OF EVENTS

<u>Date</u>	<u>School</u>	<u>Event</u>
2/7/77	Waynesburg College	John Cochenour, sales representative, borrowed my "Improvement in Teaching Metrication by Means of Performance Objectives Program" booklet and presented a lecture to the students and professors on the metric program at Waynesburg College, Waynesburg, Pennsylvania.
2/7/77	Greenock	At this faculty meeting I again demonstrated activities and experiments related to the objectives prescribed for each grade level. We, the teachers and I, discussed questions they had regarding the program.
2/14/77	Mount Vernon	The teachers and I discussed the progress and the problems they encountered in the program. Also, during this meeting I demonstrated experiments and activities to be utilized by the teachers and students.
2/15/77	Greenock and Mount Vernon	The formative evaluation for the pupils was conducted.
3/31/77	Greenock and Mount Vernon	The Teacher Formative Evaluation Form was distributed to the teachers.
4/4/77	Greenock	The use of the micrometer was explained to the teachers. I also explained how they were to give the criterion-referenced post-tests to their randomly selected pupils.

APPENDIX C (Continued)

LOG OF EVENTS

<u>Date</u>	<u>School</u>	<u>Event</u>
4/12/77	Mount Vernon	During this faculty meeting I explained to the teachers how to give the criterion-referenced post-test to their randomly selected students.
5/12/77	Greenock and Mount Vernon	The summative evaluation was administered to the students using the matrix sampling technique.

APPENDIX D**TEACHER FORMATIVE EVALUATION FORM**

TEACHER FORMATIVE EVALUATION

(Grades 1-6)

February, 1977

School _____

Grade Level _____

Please complete the checklist below
and return to your principal.

	<u>Yes</u>	<u>No</u>
1. Do you now have access to equipment and materials for teaching the metric skills assigned to your grade level?		
2. Are you teaching the metric skills?		
3. Are most of the students learning most of the metric skills assigned to your grade level?		
4. Do you understand the metric system enough to teach the metric skills that are assigned to your class?		
5. Do you need help in order to present the metric activities to your children at your grade level?		

6. Please make any suggestions or comments about the metric materials and skills being taught.

APPENDIX E

METRIC ACTIVITIES KEYED TO PERFORMANCE OBJECTIVES

ACTIVITY 1.1.1

Problem

Measure the lengths of your longest and shortest steps.

Number of Participants

Any number.

Materials

Masking tape, scissors, adding machine tape (strips of paper), pencil.

Discussion

What is the difference between a regular step and a giant step? Can you take a giant step?

Prerequisite skills

None.

Directions

1. Place a piece of masking tape on the floor.
2. Have each student put his or her toe on the masking tape and take a giant step.
3. Put a piece of tape where his or her giant step ends.
4. Cut a piece of adding machine tape the length of the student's giant step, and put the student's name on the strip of paper.
5. Once every student has a strip of paper the length of their giant step, have students order the lengths of their giant steps from longest to shortest.

ACTIVITY 1.1.1 (Continued)

Teaching Notes

An interesting bulletin board can be made by folding all the strips of adding machine tape in half, ordering them, and taping them on the wall.

Extensions

Make strips the length of a standing or running broad jump for each student.

ACTIVITY 1.2.2

Problem

Use different units of measurement to measure given lengths.

Number of Participants

Any number.

Materials

Any assortment of objects such as wooden blocks, popsicle sticks, or pieces of string.

Discussion

What is length?

Prerequisites

None.

Directions

1. Have each group of two or three students select a different unit to measure with.
2. Have the groups all measure and record the width of the door, the length of the chalkboard, and the length of the teacher's desk using their measuring unit.
3. The groups should compare their different results.
4. Discuss the reason for the differences.

Teaching Notes

The concept that the length doesn't vary but different results are obtained when different measurement objects are used is important.

ACTIVITY 1.2.2 (Continued)

Extension

Have groups of students measure various objects using the same measurement unit and then discuss any discrepancies that arise.

ACTIVITY 1.3.3

Problem

Use your own measurement unit to measure different lengths.

Number of Participants

Any number.

Materials

Soda straws, popsicle sticks, or a measurement unit the class decides upon such as a "Snoopy" or a "Cookie Monster" unit.

Discussion

If you have something to compare an object with, can you find out which object is longer or shorter? How?

Prerequisites

None.

Directions

1. As a group, decide what you are going to use as a measuring unit.
2. Select two or three objects in different parts of the room which are close to the same length.
3. Use measuring units to rank the objects as "short, shorter, shortest"; "long, longer, longest"; or "high, higher, highest."
4. Use these units to find something shorter than the shortest and something longer than the longest.

ACTIVITY 1.3.3 (Continued)

Teaching Notes

The vocabulary development is important, but the concept that something can be shorter than the shortest of a predetermined set is also very important.

Extensions

Have students measure with a metric ruler those same objects and discuss the role of a standard unit.

ACTIVITY 1.4.4

Problem

Find parts of your body which have the same lengths.

Number of Participants

Any number.

Materials

String, scissors.

Discussion

How would you measure your waist?

Why wouldn't you use a wooden ruler to measure your waist?

Prerequisite Skills

None.

Directions

1. Cut a piece of string the same length as the circumference of your ankle.
2. Can you find other parts of your body that have the same length as the circumference of your ankle.

Extension

Have students find parts of their bodies that have lengths that are greater than and smaller than the circumference of their ankles.

Have students use another part of their bodies as the basis of comparison.

ACTIVITY 1.5.5

Problem

Compare the mass of given objects.

Number of participants

Any number.

Materials

Pan balance, a nickel, various small objects (handkerchief, pencil, chalk, piece of paper, etc.) for each group of three to five students.

Discussion

Which is heavier; a pencil or a piece of chalk?

How can we find out which is heavier?

If we put one object on each side of the balance and one side of the balance goes down, and the other side goes up, which side is heavier?

Prerequisite Skills

None.

Directions

1. Have students compare the mass of the various items.
2. Have students use the nickel as a standard and compare the mass of the various items to the mass of the nickel.

Teaching Notes

The students will need instruction on using a pan balance. Many different objects can be used as the standard. Ask the student if this will change the mass of the items in each pile.

ACTIVITY 1.5.5 (Continued)

Extension

If possible obtain a 5-g mass piece and have students discover that a nickel has a mass of about 5-g. Then use a 5-g mass piece as a standard of comparison to find the mass of various items.

ACTIVITY 1.6.6

Problem

Build a cubic meter using cardboard, metric ruler and masking tape.

Number of Participants

Two to five.

Materials

Cardboard, metric ruler, masking tape, scissors or knife.

Discussion

How does the word cubic relate to measurement?

Prerequisite skills

Ability to use a metric ruler.

Directions

1. Decide how many sides a cube has.
2. Cut out or cut and tape together six cardboard squares 1 m on each side.
3. Assemble to form a cube.
4. The volume of this cube is 1 m^3 .
5. Using the cubic meter you constructed as a guide, estimate the volume of your classroom.
6. Estimate the volume of the inside of a Volkswagen in cubic meters.

Teaching Notes

Discuss the fact that a cubic meter does not have to be a cube to have a volume of 1 m^3 .

ACTIVITY 1.6.6 (Continued)

Extension

Have students find several items which have a volume of 1 m^3 .

Estimate the volume of the school in cubic meters.

ACTIVITY 1.7.7

Problem

Estimate lengths using string. Then verify your measurements.

Number of Participants

Any number.

Materials

String, scissors, centimeter cubes or strips.

Discussions

What is the value of a standard unit of measure?

What does it mean to estimate?

Prerequisites

None.

Directions

1. Measure each of the items listed below using your string as a measuring stick. Cut the string when you have found the correct measures.
 - A. Length of your little finger.
 - B. Distance around your fist.
 - C. Distance around your waist.
 - D. Distance around your wrist.
 - E. Distance around your thumb.
 - F. Length of your math book.

ACTIVITY 1.7.7 (Continued)

Directions (Continued)

- G. Distance around the handle of a baseball bat.
- H. Distance around a doorknob.
- 2. Estimate the length of each piece of string.
- 3. Now measure the length of your strings using centimeter cubes or strips.

Teaching Notes

Discuss with the students the need for standard units when communicating with each other.

Extensions

Have students compare measures to determine ratio, e.g., circumference of waist to circumference of neck.

ACTIVITY 1.8.8

Problem

Find the mass of yourself and your classmates and then graph the results.

Number of Participants

Any number.

Materials

Metric kilogram scale and piece of graph paper.

Discussion

What are some of the different ways that information can graphically be presented?

Prerequisites

The ability to accurately read a metric kilogram scale and to do basic graphing.

Directions

1. Have students determine their mass by using the metric kilogram scale.
2. Then have each student record his or her mass on a graph like the one illustrated in Figure 20.

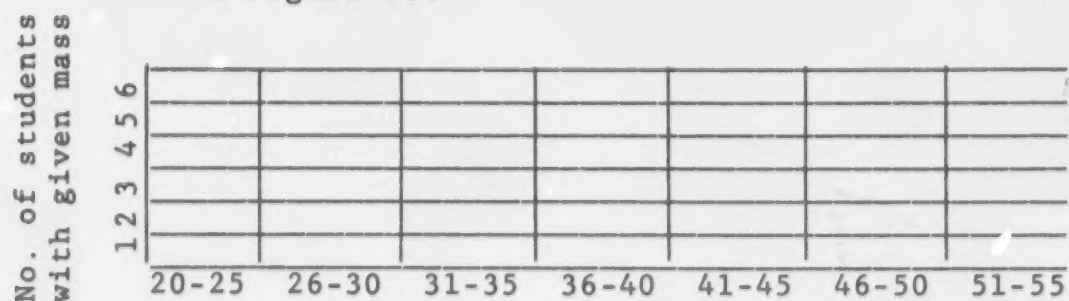


FIGURE 20. MASS IN KILOGRAMS

ACTIVITY 1.8.8 (Continued)

Teaching Notes

If a metric kilogram scale is not available, a customary scale can be used and conversion can be made by dividing the reading in pounds by 2.2. Make some colored strips of paper or tape cut in rectangles to fit the shape in the chart. If a student weighs 33 kg, a strip of tape or paper would be put in the appropriate column. When every student has recorded his or her mass, a bar graph will be the result.

Extension

This same activity could be used to compare the mass of shoes, books, etc.

ACTIVITY 1.9.9

Problem

Order objects from lightest to heaviest first by sight, then by touch, and then by using a balance.

Number of Participants

Any number.

Materials

Balance, mass pieces, an assortment of objects such as a lead fish sinker, a nut, a rubber ball, etc.

Discussion

If you have a number of boxes all looking exactly alike, what physical property is most likely to vary?

Prerequisites

Understanding of the definition and concept of terms such as larger, smaller, heavier, lighter, etc.

Directions

1. Look at the collected objects and in your mind, arrange them in a row from the lightest object to the heaviest object without touching them.
2. Rearrange the objects after lifting them with your hands.
3. Rearrange the objects after comparing them on the balance. Use the mass pieces to determine their mass.
4. Did your arrangements change in steps 1, 2 and 3? Why?

ACTIVITY 1.9.9 (Continued)

Teaching Notes

Select a wide range of objects for a more effective activity.

Extension

Have students construct or find objects of different sizes but the same mass and go through the above activities.

ACTIVITY 1.10.10

Problem

Find different ways of determining the mass of several objects. Graph your results.

Number of Participants

Any number.

Materials

Balance; centicubes or mass pieces; a number of small objects such as: Beans, nickels, pennies, dimes, assorted centimeter rods, paper clips, sheets of writing paper, pieces of chalk, thumb-tacks, straight pins, etc.

Discussion

How can one compare the differences in the masses of several objects?

Directions

1. Select a group of ten centicubes or a 10-g mass piece.
2. Place the mass pieces or centicubes on one side of the balance and complete the following statements:

It takes _____ beans to balance ten centicubes.

It takes _____ straight pins to balance ten centicubes.

It takes _____ paper clips to balance ten centicubes.

Etcetera.

3. Graph the results.

ACTIVITY 1.10.10

Teaching Notes

Let the students select many different objects.

Extension

Have students repeat the experiment using any of the larger mass pieces.

ACTIVITY 1.11.11

Problem

Use the meter measurement and find all the things in the room with a length of 1 m.

Number of Participants

Any number.

Materials

Metric ruler or strip of adding machine paper that has been premeasured to 1 m for each student.

Discussion

Why would it be important for each person to have the same length measuring device when we are measuring the same objects?

Prerequisite Skills

None.

Directions

1. Using your metric ruler (strip of paper) find all the things that are about 1 m long in your room.
2. How many things can you find that are just a little longer than 1 m?
3. How many things can you find that are just a little shorter than 1 m?

Teaching Notes

This activity can lead naturally into a discussion of multiple and divisions of a unit length.

ACTIVITY 1.11.11 (Continued)

Extension

Have students find objects that are equal to, longer than, or shorter than 0.5 m.

ACTIVITY 1.12.12

Performance Objective

The student will learn to use a metric ruler to measure in centimeters.

Problem

Determine the metric measure of the tails of the animals.

Number of Participants

Any number.

Materials

Set of animals (monkeys, cats, opossum, etc.) with different lengths string for tails, metric ruler.

Discussion

Are the tails of the animals you have all the same size?

Suppose you could not move the animals, how could you find out which animal had the longest tail?

Prerequisite Skills

None.

Directions

Order your animals from the animal with the longest tail to the animal with the shortest tail.

Teaching Notes

This would be a good exercise to introduce the reading of centimeters on the metric ruler.

ACTIVITY 1.12.12 (Continued)

Extension

Have students measure the tail of each animal. Other animal pictures could be used, with string in lieu of part of their body. The bodies of various animals could be measured.

ACTIVITY 1.13.13

Problem

Using a trundle wheel determine if the perimeter remains constant when the shape of the figure changes.

Number of Participants

All class members.

Materials

Trundle wheel.

Discussion

As you change figures, what will happen to the distance around the outside?

Prerequisite Skills

None.

Directions

1. Students will clasp hands to form a large circle. They are to stretch out as far as they can.
2. With the trundle wheel determine the distance around the outside.
3. Determine if the distance changes when the students form:
 - A. A rectangle of various lengths and widths.
 - B. A square.
 - C. A triangle.
 - D. An oval.

ACTIVITY 1.13.13 (Continued)

Teaching Notes

This activity can help students get a good understanding of perimeter and gives them practice in measuring with a trundle wheel.

Extensions

Repeat the same activity using string.

ACTIVITY 1.14.14

Problem

Find out how many milliliters of water it will take to fill the various containers.

Number of Participants

Any number.

Materials

250-ml beaker, 500-ml beaker, liter container, and various containers.

Discussion

How many beakers of water would it take to fill the liter container?

How could we check to see if our answer is correct?

Prerequisite Skills

None.

Directions

1. Have students estimate how many small (250 ml) beakers of water it would take to fill a liter container.
2. Check estimate by filling liter container with small beakers of water.
3. Now estimate and check to see how many 250-ml beakers of water it would take to fill various containers.

Teaching Notes

This is a concept that may require a great deal of experimentation before the child becomes comfortable with it.

ACTIVITY 1.14.14 (Continued)

Extension

Students could use the 500-ml beaker as a measuring device.

ACTIVITY 1.15.15

Problem

Decide if an object is heavier or lighter than a predetermined mass and check the accuracy of your decision by using the balance.

Number of Participants

Any number.

Materials

Balance; centicubes or selected mass pieces; an assortment of small objects such as: A pencil, a quarter, eyeglasses, various centimeter rods, paper clips, a chalkboard eraser, a piece of chalk, etc.

Discussion

How does a person learn to estimate accurately?

Is there a need to have a mental picture of the mass 10 g or 25 g?

Prerequisites

None.

Directions

1. Select ten centicubes or a 10-g mass piece.
2. Arrange the objects which are lighter than the selected mass piece to the left of it and heavier than the mass piece to the right of it.
3. Check your arrangement on your balance. Reorder them if necessary.
4. Repeat the experiment using a number of different mass pieces.

ACTIVITY 1.15.15 (Continued)

Teaching Notes

Select several groups of objects that the student must work through with the different mass pieces. This will give needed practice in developing a concept of metric mass measurements.

Extension

Try this experiment with the student blindfolded.

ACTIVITY 1.16.16

Problem

Find the thickness of a playing card.

Number of Participants

Any number.

Prerequisites

Ability to use and read to the nearest millimeter the micrometer and/or metric ruler.

Directions

1. Using your micrometer and/or metric ruler, find the thickness of ten cards. Use millimeters as your unit of measure.
2. Once you have determined the thickness of ten cards, determine what the thickness of one card would be without measuring.

Teaching Notes

Stress the following types of relationships to the students:

$$\begin{aligned}75 \text{ cm} &= 0.75 \text{ m} \\75 \text{ mm} &= 0.075 \text{ m} \\75 \text{ mm} &= 7.5 \text{ cm}\end{aligned}$$

If the students need practice, have them do some practice exercises showing the moving of the decimal point when you are dividing by 10.

Extensions

Find the thickness of one page in a book using the above procedure. The student may need to measure more than ten pages.

ACTIVITY 1.17.17

Problem

Using vernier calipers, measure parts of your body and various parts of your environment.

Number of Participants

Any number.

Materials

Large vernier calipers.

Discussion

What types of objects would you measure with vernier calipers?

Prerequisites

Ability to read and use a vernier caliper.

Directions

1. Using the vernier calipers, estimate and then measure the following items in the classroom:
 - A. Width of your shoulders.
 - B. Width of your head.
 - C. Thickness of five dictionaries.
 - D. Thickness of table.
 - E. Diameter of a soccer ball.
2. Using the vernier calipers, estimate and then measure the following items found outside:
 - A. Diameter of tree.

ACTIVITY 1.17.17 (Continued)

- B. Width of stop sign.
- C. Width of bicycle tire.
- D. Thickness of the flagpole.

Teaching Notes

A workable vernier caliper can be made by using two T-squares or carpenter squares and a metric ruler.

Extensions

Many other objects can be measured besides those mentioned.

ACTIVITY 1.18.18

Problem

Determine the number of units needed to cover each area.

Number of Participants

Any number.

Materials Needed

Centimeter cubes or blocks or squares such as wooden blocks.

Discussion

How would we measure a surface?

Prerequisite Skills

Ability to count.

Recognition of square and rectangle.

Directions

1. Make an outline of a square or rectangle using the centimeter cubes or blocks.
2. Predict the number of centimeter cubes or blocks it would take to fill the inside.
3. Fill the inside of the figure. How many blocks did it take to fill the inside?
4. Determine the number of blocks used in all.
5. Repeat for a wide variety of sizes and shapes of rectangles.

ACTIVITY 1.18.18 (Continued)

Teaching Notes

Colored rods can be very beneficial here if the student is quite familiar with them. Make perimeters with different rods and the student will relate a color with a number and likely eliminate a lot of counting.

Extension

Have students form a square and predict the number of units needed for a border.

ACTIVITY 1.19.19

Problem

Determine the area you would occupy if you were rectangular in shape.

Number of Participants

Any number.

Materials

Metric ruler and masking tape.

Discussion

Why is the square the easiest surface area to determine?

Prerequisite Skills

Ability to understand the concept of area.

Ability to multiply.

Directions

1. Stand against a wall with your arms outstretched.
2. Have a friend place a small piece of masking tape to mark the top of your head and the end of each of your outstretched hands.
3. Measure from the floor to the tape above your head. It was how many centimeters?
4. Measure from one piece of tape to the other that marked your outstretched hands. It was how many centimeters?
5. Determine the area you would cover if you were the shape of the rectangle marked by the tape on the wall.
6. Were you a square?

ACTIVITY 1.19.19

Teaching Notes

Students may express their measurements in two units such as 1 m, 20 cm. This does not take advantage of the simplicity of the metric system.

Extension

Determine the area on the wall by using an overhead projector and shining a transparent grid with traced outline. Will the area vary as the distance of the overhead from the wall changes? How would you obtain standard measurements using this procedure?

ACTIVITY 1.20.20

Problem

Make baseball, basketball and football metric sports.

Number of Participants

Small groups work best.

Materials

Trundle wheel or metric tape measure.

Discussion

Since all international sports are metric, will metrication affect American sports?

Prerequisite Skills

Ability to use trundle wheel or measuring tape.

Directions

1. Using the trundle wheel or metric tape, measure the base lines on a ball diamond.
 - A. How far in metric units would you have to run if you hit a home run?
 - B. How far in metric units would you have to hit a ball to hit a metric home run at the local ball field?
2. Measure the basketball court.
 - A. What is the metric area of the court?
 - B. How far in metric units would you have to run if you ran 20 laps around the perimeter during practice?

ACTIVITY 1.20.20 (Continued)

3. Using the trundle wheel or metric tape, measure your football playing area.
 - A. What is the area of the football playing field?
 - B. What dimensions would you recommend for a metric football field?

Teaching Notes

Have students express dimensions in general units instead of exact metric measurements. For example, a home run will be how many meters in length?

Extension

Help students set up a "metric" track meet for your class or school.

ACTIVITY 1.21.21

Problem

Determine how many squares are need to make a cube.

Number of Participants

Any number.

Materials

Centimeter unit rods or blocks, centimeter multibase cubes or blocks.

Discussion

How would you measure a cube?

Prerequisite Skills

Recognition of basic shapes and solids.

Directions

1. Form a square using centimeter units or cubes.
2. Predict the number of rods it would take to make a cube with a height equal to the dimensions of the square.
3. Determine the number of rods used in all.
4. Repeat for a wide variety of square bases.

Teaching Notes

A number of these experiences build a foundation from which you can help the students develop a "formula" for finding the volume of a cube. When someone does find a workable rule, name it after him or her (i.e. "Bob's Rule or Kay's Rule for Finding Volume").

ACTIVITY 1.21.21 (Continued)

Extension

Build bases that are rectangular and then extend them vertically and try to develop a rule for finding the volume of any rectangular solid.

ACTIVITY 1.22.22

Problem

Make a container that will hold a liter and compare the liter to the quart.

Number of Participants

Three or four.

Materials

16 cm x 28 cm paper, 20 cm x 20 cm cardboard, tape (scotch or masking), quart jar, beans or puffed rice.

Discussion

What things will we measure in liters?

Prerequisite Skills

None.

Directions

1. Form a cylinder by taping the 16-cm edges of paper together. This cylinder will hold approximately 1 liter.
2. Fill the cylinder with puffed rice or beans--be sure to hold the 20 cm x 20 cm cardboard at the bottom of the cylinder to keep the puffed rice or beans from spilling.
3. Pour the puffed rice or beans from the cylinder into the quart jar.
4. Which is larger, the liter or the quart jar?

Teaching Notes

Discuss milk carton capacities compared to the liter.

ACTIVITY 1.22.22 (Continued)

Extension

Determine how many liters it takes to fill a half-gallon jar. Measure a half-gallon container of milk. Can you make a liter container from it? Discuss what metric-size containers should be used for bottling milk and soft drinks.

ACTIVITY 1.23.23

Problem

Determine the least number of mass pieces you need to weigh any object having a mass greater than 1 g but less than 100 g.

Number of Participants

Any number.

Materials

None.

Discussion

To find the mass of an object that weighs 6 g, do we necessarily need a 6-g mass piece? What combination of mass pieces could be used instead?

Prerequisites

Good facility in simple addition and subtraction.

Directions

Given a simple pan balance, determine the least number of mass pieces you need to construct in order to find the mass of any object having a mass greater than 1 g but less than 100 g.

Teaching Notes

Careful recording of the mass pieces selected is very important.

Extension

The students may explore what mass pieces are needed to find masses up to a kilogram.

ACTIVITY 1.24.24

Problem

Find two factors that influence the boiling point of water.

Number of Participants

Any number.

Materials

Pan for boiling water, hot plate, Celsius thermometer, sugar (1 cup), and salt (1 cup).

Discussion

At what metric temperature does water boil?

Are there factors that could change the boiling point of water? If so, what are they?

Prerequisite Skills

Knowledge of laboratory procedure.

Directions

1. Put water in the pan and heat the water until it boils. Record the temperature using the Celsius thermometer. Be careful to keep the thermometer off the bottom of the pan.
2. Add salt slowly to the boiling water. Stir constantly and record temperature every minute or two.
3. Record your findings.
4. Repeat steps 1 to 3 using sugar in place of salt.
5. What are your findings?

ACTIVITY 1.24.24 (Continued)

Teaching Notes

This may be an activity that you will want to perform. If you do the activity, have students read the thermometer and record the findings. Discuss the results.

Extension

Determine the length of time it takes to get equal amounts of water from 50°C to 90°C, once with the pan uncovered and once with a lid on the pan.

ACTIVITY 1.25.25

Problem

Find one factor that will lower the freezing point of water.

Number of Participants

Any number.

Materials

Pan of ice, Celsius thermometer, and a cup of salt.

Discussion

How is ice cream made in an ice-cream mixer?

Prerequisite Skills

Ability to read a Celsius thermometer.

Directions

1. Place thermometer in pan of ice water and after several minutes record temperature.
2. Wait ten minutes and record the temperature again.
3. Carefully stir a cup of salt into the pan of ice water.
4. Keep stirring and record the Celsius temperature every few minutes until there is no change for three minutes.
5. Graph your results.
6. What are your findings?

ACTIVITY 1.25.25 (Continued)

Teaching Notes

Be sure to have an adequate supply of ice. Keep adding ice and salt to the pan until the temperature makes no change for three minutes. The graph can be done as a class activity.

Extension

Look up the history of the Fahrenheit experiment that led to the development of the thermometer. Determine where the name Celsius came from.

ACTIVITY 1.26.26

Problem

Find the length of various parts of your body, e.g., hand span, reach, height, width of little finger, etc.

Number of Participants

Any number.

Materials

String, scissors, metric ruler, or metric tape measure.

Discussion

What would be the value of knowing your measurements? Could you use this knowledge to measure other objects? How?

Prerequisites

Ability to estimate.

Ability to read and use a metric ruler or metric tape measure.

Directions

1. Decide on an appropriate unit of measure.
2. Estimate and then measure each of the following:
 - A. Hand span (fingers spread wide apart).
 - B. Reach (both arms outstretched).
 - C. Height.
 - D. Width of little finger.

ACTIVITY 1.26.26 (Continued)

- E. Circumference of neck.
- F. Length from elbow to end of longest finger.
- G. Length from nose to end of outstretched hand.

Teaching Notes

If a metric ruler is used, have children measure the parts of their bodies using string and then have them measure the string to determine body measurements.

Extension

Have the students measure various objects in the room utilizing their body measurements. Then have them use the metric ruler to actually measure the objects. How do these measurements compare?

ACTIVITY 1.27.27

Problem

Determine how many square meters of carpeting you would need to carpet your school's halls.

Number of Participants

Any number.

Materials

Metric tape measure or trundle wheel.

Discussion

What does it mean to find the area of a rectangle?

Why can you multiply the length by the width of a rectangle to find its area?

Prerequisite Skills

Ability to use a tape measure or trundle wheel.

Knowledge of formula for finding area.

Directions

1. With your trundle wheel or tape measure, find the dimensions of the halls in your school.
2. Calculate the area of all of the halls. How many square meters of carpeting would you have to buy to carpet your school's halls?
3. If the school could get the carpeting for \$9.00 per square meter, how much would it cost to carpet your school halls?

ACTIVITY 1.27.27 (Continued)

Extension

Students could find out how much it would cost to carpet all of the classrooms.

ACTIVITY 1.28.28

Problem

Make a metric scale drawing of your school grounds and, using this drawing, find the area of the grounds.

Number of Participants

Groups of three work best.

Materials

Trundle wheel or metric tape measure.

Discussion

If the school grounds were not uniform in shape, what procedure could be used for measuring it?

Prerequisite Skills

Ability to measure with a trundle wheel.

Facility in determining area and perimeter.

Knowledge of scaling.

Directions

1. Find the perimeter of your school ground using the metric trundle wheel.
2. Make a metric scale drawing of your school ground.
3. From your scale drawing find the area.
4. Check your scale drawing with that of other groups to see if they agree.
5. Find the average of the different areas of measurement obtained.
6. Compare the average area to the actual area (if available).

ACTIVITY 1.28.28 (Continued)

Teaching Notes

It would be good to check your metric measurements against information the principal can provide. Be sure to use the conversion charts in Appendix E to change the measurements to metric so the comparison will be valid. Do not have students do this conversion!

Extensions

Draw a metric scale drawing of your school.

ACTIVITY 1.29.29

Problem

Estimate and then verify the number of specified small unit areas in a given larger area.

Number of Participants

Any number.

Materials

Centimeter grid paper.

Discussion

How would you go about estimating the number of unit squares in a rectangle? The number of unit rectangles in a rectangle?

Prerequisite Skills

Understanding of the concept of area.

Directions

1. Draw a rectangle 10 cm by 16 cm on the grid paper.
2. Estimate or calculate the number of 3 cm. by 4 cm rectangles you can cut from the rectangle.
3. Try it!
4. Were you right?
5. Repeat steps 1, 2 and 3 and this time calculate the number of 2-cm squares you can cut from the rectangle.

ACTIVITY 1.29.29 (Continued)

Teaching Notes

Have each student keep a record of the number of rectangles he or she cuts to see who can get the most.

Extension

Students can work up variations of their own. Have them try for a minimum number of a maximum number.

ACTIVITY 1.30.30

Problem

By knowing the length of one side of a square, determine its area.

Number of Participants

Any number.

Materials

Grid paper.

Discussion

Why can you express 6×6 as 6^2 ?

Prerequisite Skills

Knowledge of the multiplication facts.

Directions

1. Draw a square 1 cm in length on each side.
2. Determine its area.
3. Draw squares 2, 3, 4, 5 and 6 cm on each side.
4. Determine the area of each square.
5. Predict the area of squares that measure 8, 10 and 12 cm on each side.

Teaching Notes

Point out that for teaching beginning area measurement we use figures we can express as squares, but area measurement need not be restricted to squares.

Extensions

Have students see if a pattern exists for equilateral triangles with side length of 1 cm.

ACTIVITY 1.31.31

Problem

Estimate, then check your estimate of the capacity of various bottles.

Number of Participants

Any number.

Materials

Graduated cylinder and several different-sized bottles.

Discussion

Have students estimate the capacities of the bottles.

Prerequisite Skills

Ability to read a graduated cylinder.

Directions

1. Estimate the capacities of the bottles and order the bottles by capacity from smallest to largest.
2. Find the capacity of each bottle in milliliters.
3. Re-order the bottles if necessary.

Teaching Notes

Discuss "frame of reference" for metric capacity measures. Students should pick a common reference to become familiar with capacity measure.

ACTIVITY 1.31.31 (Continued)

Extension

Have labels with correct capacities written on them. Show bottles one at a time and have students try to place the correct label on each bottle.

ACTIVITY 1.32.32

Problem

Find the volume of a box in the customary and metric systems.

Decide which method is easier.

Number of Participants

Any number.

Materials

Empty box (shoebox is fine), yardstick, and metric ruler.

Discussion

How do you find volume?

What is the formula for finding volume of a rectangular solid?

Prerequisite Skills

Ability to compute volume using formula
 $l \times w \times h$.

Directions

1. Measure the dimensions of the box using the yardstick.
2. Find the volume of the box using the formula $l \times w \times h$.
3. Record the volume of the box in cubic yards.
4. Now measure the dimensions of the box using the metric ruler.
5. Find the volume of the box using the formula $l \times w \times h$.

ACTIVITY 1.32.32 (Continued)

6. Record the volume of the box in cubic meters.
7. Which system was the easier to use?

Teaching Notes

Discuss which measuring system was the easier to use. The most accurate. The fastest. Be careful that the students determine the volume of a cubic yard by using 36 in. x 36 in. x 36 in.

Extension

Find the volume in cubic feet.

Find the volume in cubic centimeters.

ACTIVITY 1.33.33

Problem

Find the mass of unpopped corn, then pop the corn and find its mass. Explain the difference between the two masses.

Number of Participants

Small groups of two to five.

Materials

Balance, mass pieces, popcorn, and popper.

Discussion

What will happen to the volume of the corn during popping?

What do you predict will happen to the mass of the corn? Why?

Prerequisites

None.

Directions

1. Carefully weigh out approximately 50 g of unpopped corn.
2. Record the mass.
3. Pop the corn.
4. Record the mass of the popped corn.
5. Is there a difference? Why?
6. Eat the corn.

Teaching Notes

If the students are quite young, do as a class-room demonstration.

ACTIVITY 1.33.33 (Continued)

Extension

Have the students perform similar experiments on other foods, such as soaking beans in water.

ACTIVITY 1.34.34

Problem

Find the relationship that exists between mass and capacity.

Number of Participants

Any number.

Materials

Pan balance, two paper cups, mass pieces and a graduated cylinder.

Discussion

Why is it convenient to have a relationship between mass, capacity and volume in a measuring system?

Prerequisites

Ability to use a balance.

Ability to read a graduated cylinder.

Directions

1. Place a paper cup on each side of the pan balance.
2. In one paper cup put one of your mass pieces, in the other carefully pour water until the scale is balanced.
3. Measure the amount of water used to balance the scale in the graduated cylinder.
4. Repeat this with several mass pieces.
5. What relationship exists between mass and capacity?

ACTIVITY 1.34.34 (Continued)

6. Using water, determine the mass of several objects, then check your results using your mass pieces.

Teaching Notes

If needed, a baby bottle will serve as a fairly accurate graduated cylinder.

Extensions

Challenge students to use the reverse of the above procedure in order to make a graduated cylinder from a tall thin bottle.

ACTIVITY 1.35.35

Problem

Find the Celsius temperature for the boiling point and freezing point of water, a comfortable room and your normal body temperature.

Number of Participants

Any number.

Materials

Celsius thermometer.

Discussion

What are the Fahrenheit temperatures for:

1. Boiling water.
2. Freezing water.
3. Room temperature.
4. Body temperature.

Prerequisite Skills

Knowledge of common Fahrenheit temperatures..

Ability to read thermometer.

Directions

Using the Celsius thermometer, determine the Celsius temperature for:

1. Boiling water.
2. Freezing water.
3. A comfortable room temperature.
4. Normal body temperature.

ACTIVITY 1.35.35 (Continued)

Teaching Notes

It is best if students actually perform experiments to determine the temperatures. However, if this is not possible have students read a dual-scale thermometer to give them needed practice.

Extensions

Have students build a thermometer to practice reading temperatures. They could make one by threading a continuous ribbon through poster board and coloring half of the ribbon red.

ACTIVITY 1.36.36

Problem

Using scale measurement, find the distance from Phoenix to various parts of the world on your globe.

Number of Participants

Groups of three.

Materials

Globe, string and metric ruler (or metric tape measure in place of string and metric ruler).

Discussion

Are distances found on the globe exact or approximate?

Would the error of measurement be greater or less on a city map? Why?

What is a scale drawing? When do we use them?

Prerequisites

Familiarity with globe.

Ability to read and use a metric ruler or metric tape measure.

Ability to perform division operation.

Understanding of scale measurement.

Directions

1. Using the string, measure the equator of your globe.
2. The length of the equator is approximately 40,000 km.

ACTIVITY 1.36.36 (Continued)

3. The scale of your globe becomes
1 cm = _____ km.
4. Use this scale to find the following distances:
 - A. Phoenix to New York.
 - B. Phoenix to London.
 - C. Phoenix to Capetown.
 - D. Phoenix to Mexico City.
 - E. Phoenix to Tokyo.
 - F. Phoenix to Moscow.

Teaching Notes

Help students find the scale measure by taking the length of the string and dividing this number into 40,000 km.

Extensions

Have students find other distances by replacing Phoenix with their home city. Have students exchange globes and do the same discovery exercises again to see if using different-sized globes would produce different scales.

ACTIVITY 1.37.37

Problem

Determine if the surface area changes as the shape of the figure changes.

Number of Participants

Any number.

Materials

Twelve centicubes or centimeter rods for each player.

Discussion

When the shape of a figure changes, how does this affect the surface area?

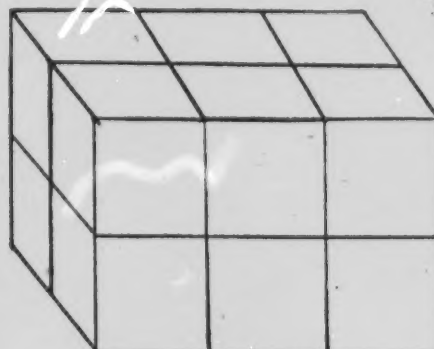
Prerequisites

Understanding of the concept of surface area.

Directions

1. Place 12 cubes or rods in an arrangement as shown in Figure 16.
2. How many squares 1 cm x 1 cm are on the outside surface of the figure? (Don't forget the bottom.)

Figure 16.



ACTIVITY 1.37.37 (Continued)

3. Change the shape of the figure. Did the surface area remain the same?
4. What would be the largest area that can be exposed by one solid figure made up of 12 centicubes or rods?
5. What would be the smallest area that can be exposed by one solid figure made up of 12 centicubes or rods?
6. Repeat with 16 centicubes or rods.

Teaching Notes

If neither of these materials are readily available, sugar cubes will work very well.

Extension

Have the students generalize when they will obtain a maximum and minimum surface area.

ACTIVITY 1.38.38

Problem

Determine if there is a relationship between the perimeter and the area of an object.

Number of Participants

Any number.

Materials

Centimeter grid paper or metric ruler.

Discussion

How are perimeter and area related?

What shape gives the largest area? Largest perimeter?

Directions

1. Draw a series of rectangles on the centimeter grid paper, all having a perimeter of 36 cm, but having the following dimensions:

	<u>Perimeter</u>	<u>Area</u>
A. 1 cm by 17 cm		
B. 2 cm by 16 cm		
C. 3 cm by 15 cm		
D. 4 cm by 14 cm		
E. 5 cm by 13 cm		
F. 6 cm by 12 cm		
G. 7 cm by 11 cm		
H. 8 cm by 10 cm		
I. 9 cm by 9 cm		

ACTIVITY 1.38.38 (Continued)

2. Find the perimeter and area of each rectangle and record it in the chart.
3. Repeat experiment but this time keep the area constant. What happens to the perimeter?

Teaching Notes

Have each student make a chart to record the results. Discuss what is the best way to represent the information so a conclusion can be made. Guide the students to make conclusions based on their findings.

Extension

Have students try other shapes to see if the square gives the most area for the least perimeter. Graph the results.

ACTIVITY 1.39.39

Problem

Estimate and then verify the area and length of a given sheet of paper.

Number of Participants

Any number.

Materials

Adding machine tape or strips cut from butcher paper.

Discussion

What is your prediction of what will happen to the strip as you cut along the lines? Why?

Prerequisite Skills

Ability to calculate area.

Directions

1. Use a piece of adding machine tape or other paper about 70 cm long and 5 to 7 cm wide.
2. Find the area of the paper.
3. Find the perimeter of the paper.
4. Give the paper a half twist and tape the ends together.
5. Draw a line down the center of the paper.
What happened?
6. Predict what will happen to the strip of paper when you cut on the line.
7. Find the area of the resulting piece or pieces in square centimeters.

ACTIVITY 1.39.39 (Continued)

8. Find the perimeter.

Teaching Notes

Advanced students may be interested in doing some research in topology in general and mobius strips in particular.

Extension

Perform the same activity with a full twist in the paper.

ACTIVITY 1.40.40

Problem

Find the capacity of various containers.

Number of Participants

Three to five.

Materials

Graduated cylinder, large jug, pop bottle (any size), juice glass, mustard bottle, vanilla bottle (any size), other bottles.

Discussion

What is meant by volume?

What is meant by capacity?

Prerequisite Skills

Ability to read a graduated cylinder.

Directions

1. Fill a graduated cylinder with water to the 100-ml mark.
2. Pour this into a large jar. This equals 0.1 liter.
3. Pour ten of these 0.1 liter measures into the large jar. This is equal to a liter.
4. Estimate and then measure the capacity of the following:

	<u>Estimate</u>	<u>Measure</u>
A. Pop bottle	_____	_____
B. Juice glass	_____	_____
C. Mustard bottle	_____	_____
D. Vanilla bottle	_____	_____

ACTIVITY 1.40.40 (Continued)

E. Any container _____

Teaching Notes

Discuss the effect of shapes of the bottles on capacity.

Extension

Have students estimate the capacity of very large containers, such as an automobile gas tank, in liters. Then find brochures which list capacities to compare answers.

ACTIVITY 1.41.41

Problem

Estimate what would happen to the volume of a box if you double and then triple its dimensions. Build the boxes and see if you were correct.

Number of Participants

One to three.

Materials

Paper, scissors, and tape (scotch or masking), puffed rice or sand.

Discussion

When you double the dimensions of a box, what happens to the volume?

Prerequisite Skills

Ability to measure and construct boxes.

Directions

1. Suppose you had a cube that was 1 dm x 1 dm x 1 dm and you filled the cube with rice or sand. How much rice or sand would the cube hold?
2. Now suppose you made each side 2 dm x 2 dm x 2 dm. How much rice or sand would the new container hold?
3. Next suppose you make each side three times as long as the original cube. How much rice or sand would this container hold?

ACTIVITY 1.41.41 (Continued)

4. Take some paper, scissors and tape. Make the containers in steps 1, 2 and 3 and check to see if the volume you predicted was correct. Check your answers by filling containers with water then pouring the contents into a graduated cylinder. Remember, $1 \text{ ml} = 1 \text{ cm}^3$.

Teaching Notes

Students have a difficult time giving volume when doubling each side. Naturally they think volume doubles. Be sure to have the students actually do the experiment so he or she will observe the actual increase in volume.

Extension

Have the student double one side and find out if the volume doubles.

Have the student double two sides and determine the volume.

Have the student predict what would happen to the volume of a cube if you increase each side ten times.

Solve the problem.

ACTIVITY 1.42.42

Problem

Determine if there is a relationship between mass and volume.

Number of Participants

Three to five.

Materials

Ten centicubes, water, balance, metric mass pieces and graduated cylinder.

Discussion

How can you increase accuracy when measuring with small units?

Prerequisite Skills

Ability to use a balance.

Ability to read a graduated cylinder.

Directions

1. Find the mass of the centicube using the balance. (To be more accurate, find the mass of ten centicubes then divide by 10.)
2. Drop the centicube into a graduated cylinder with 20 ml of water in it. Make sure it sinks.
3. Now what is the reading of the graduated cylinder?
4. Drop four more centicubes into the graduated cylinder.
5. Now what is the reading of the graduated cylinder?

ACTIVITY 1.42.42 (Continued)

6. What was the average volume of each centicube?

Teaching Notes

Be sure to stress that centicubes are carefully constructed so that 1 cm^3 piece has a mass of 1 g.

Extension

Have students determine if this same activity will work using centimeter rods. Why?

ACTIVITY 1.43.43

Problem

Find the volume of a brick and a coffee can.

Number of Participants

Three or four.

Materials

Depth gauge, vernier calipers, diameter gauge, coffee can (any size) and brick (any size).

Discussion

What is π equal to?

What is the difference between volume and capacity?

Prerequisite Skills

Knowledge of and ability to use volume formulas for cylinders and rectangular solids.

Directions

1. Measure the length, width and height of the brick using the calipers.
2. Determine the volume of materials used in the construction of the brick using the formula $v = l \times w \times h$. If the brick has a hole in it, be sure to subtract the volume of the hole from the total volume.
3. Measure the inside diameter of the coffee can using the diameter gauge.
4. Measure the height of the coffee can using the depth gauge.

ACTIVITY 1.43.43 (Continued)

5. Compute the volume of the coffee can using the formula $v = (3.14 \times d^2 \times h)/4$ where d is the inside diameter and h is the depth of the can.

Teaching Notes

Try to use a brick such as a cinderbrick so the student will need to subtract the open volume from the total volume.

Extension

Find volumes of different kinds of containers.

ACTIVITY 1.44.44

Problem

Find the mass of a dollar's worth of quarters, dimes nickels and pennies.

Number of Participants

Any number.

Materials

Balance, mass pieces and several quarters, dimes, nickels and pennies.

Discussion

Is any part of our money system metric?

Would there be advantages to having our coins metric?

Prerequisites

Ability to find mass accurately.

Ability to multiply and divide.

Directions

1. Find the mass of a dollar's worth of:
 - A. Quarters.
 - B. Dimes.
 - C. Nickels.
 - D. Pennies.
2. If you were to buy coins by mass, which coin would be the best buy?

ACTIVITY 1.44.44 (Continued)

Teaching Notes

Have students find a combination of small coins that would balance larger coins such as the quarter, half dollar and, if available, the dollar coin.

Extension

Have students find as many combinations of coins as possible that total 50 cents. Determine the mass of each combination.

ACTIVITY 1.45.45

Problem

Estimate in Celsius degrees what the typical July temperature would be in cities marked on a map. Verify your results using an encyclopedia.

Number of Participants

Any number.

Materials

Prepared worksheet.

Discussion

Will there be more below zero temperature days in Celsius measurement than there have been in Fahrenheit measurement or vice versa? Why?

Prerequisite Skills

None.

Directions

1. Place what you think would be a typical July Celsius temperature next to the cities marked on the map.
2. Check your answers by looking for typical temperatures in the encyclopedia.

Teaching Notes

Be sure to clarify normal climate conditions for any region which the students are unfamiliar with.

Extension

Repeat activity using a world map.

APPENDIX F

CRITERION-REFERENCED TESTS
KEYED TO PERFORMANCE OBJECTIVES

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.1.1.1

Grade 1

School _____

Date _____

Directions:

The student is to compare the lengths of the lines below. Read the directions to him/her and mark below if the answers are right or wrong. Put a mark by the word "right" if both answers are correct. If one or more answers are wrong, put a mark by the word "wrong."

Read Aloud:

Look at the lines below. Draw a circle around the longest line. Put an "X" on the shortest line.

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.2.2.2

Grade 1

School _____

Date _____

Direction:

The student is to measure the line below using strips of paper (attached) to determine if the length of an object changes when different measuring units are used. Give the student the test paper and the strips of paper (attached).

Read Aloud:

Measure the length of the line below using your black strip of paper. Now measure the line with your three strips of red paper. Is the line longer when measuring with the black strip of paper, the three red strips of paper, or does the line stay the same length?

Put a check mark by the student's answer:

Black paper _____

Red paper _____

It stays the same length _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.3.3.3

Grade 1

School _____

Date _____

Directions:

The student is to measure the length of the test paper using the blue strip of paper (attached). Record the student's answer below.

Read Aloud:

Measure how long the white test paper is by using the blue strip of paper. The test paper is how many blue strips long?

Circle One:

1 blue strip

2 blue strips

3 blue strips

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.4.4.4

Grade 1

School _____

Date _____

Directions:

The student is to place his/her strip of paper (attached) on the line segment below that is of equal length. Check his answer and mark below if it is right or wrong.

Read Aloud:

Circle the line below that is as long as your yellow strip of paper.

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.5.5.5

Grade 1

School _____

Date _____

Directions:

The student is to compare the mass of his mathematics book and his pencil to determine if his pencil is "heavier than" or "lighter than" his book. Record his answer below.

Read Aloud:

Pick up your math book. Now pick up your pencil. Is the pencil "Lighter than" or "heavier than" the math book?

Check One: Lighter than _____

Heavier than _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.6.6.6

Grade 2

School _____

Date _____

Directions:

The student is to determine if the cardboard box provided is bigger or smaller than a cubic meter. Record the student's answer below after displaying the box.

Read Aloud:

Is this box bigger than or smaller than a cubic meter?

Check One: Bigger than _____

Smaller than _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.7.7.7

Grade 2

School _____

Date _____

Directions:

The student is to measure the line segment below using centimeter cubes. Provide the student with sufficient centimeter cubes.

Read Aloud:

How many centicubes long is the line below?
Use the centimeter cubes to measure it.
Write your answer on the line.

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.8.8.8

Grade 2

School _____

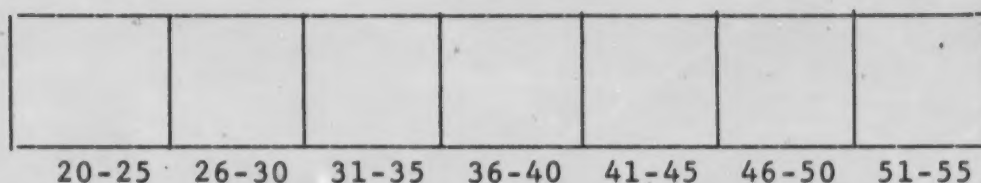
Date _____

Directions:

The student is to determine his mass by using a metric kilogram scale and record his mass on the graph below. Check the student's answer and mark whether it is right or wrong below.

Read Aloud:

Use the metric kilogram scale to find your mass and mark it on the graph below.



MASS IN KILOGRAMS

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.9.9.9

Grade 2

School _____

Date _____

Teacher's Directions:

Given a pan balance, the large ball provided and the sinker provided, the student is to determine which object has greater mass. Check his/her answer and mark below if it is right or wrong.

Read Aloud:

Use the pan balance, the large ball and the sinker and find which object has greater mass. Answer the question below.

Which object has greater mass, the ball or the sinker?

Circle One: Ball Sinker

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.10.10.10

Grade 2

School _____

Date _____

Directions:

The student is to use the balance scale to determine the number of lima beans that is equal to a 10-g mass piece. Check the student's answer and mark whether it is right or wrong below.

Read Aloud:

Using the balance scale, a 10-g mass piece, and beans, tell how many beans are equal to a 10-g mass piece.

Circle One: 5

9

13

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.11.11.11

Grade 3

School _____

Date _____

Directions:

The student is to measure the width of the classroom to determine, to the nearest meter, its width. Check his answer and mark whether it is right or wrong.

Read Aloud:

Use the meter stick and measure to the nearest whole meter the width of the classroom. Write your answer on the line below.

Answer: _____

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.12.12.12

Grade 3

School _____

Date _____

Directions:

The student is to use a metric ruler to measure in centimeters. Check the student's answer and mark below whether it is right or wrong.

Read Aloud:

Measure the line below to the nearest centimeter using your metric ruler and write your answer on the line.

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.13.13.13

Grade 3

School _____

Date _____

Directions:

All the students in the class are to form a circle and then a square. The student is to measure the distance around the circle and then around the square using a trundle wheel. Check the student's answer and mark below if it is right or wrong.

Read Aloud:

Did the distance around the outside change as the students changed from a circle to a square?

Circle One: Yes No

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.14.14.14

Grade 3

School _____

Date _____

Directions:

The student is to determine the capacity of a 7-ounce bottle in milliliters, given sufficient water and the graduated liter cube. Check the student's answer and record whether it is right or wrong below.

Read Aloud:

Use the water, the liter cube and the 7-ounce bottle to find how many milliliters of water a 7-ounce bottle can hold. Write your answer on your test paper.

Answer: _____ ml

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.15.15.15

Grade 3

School _____

Date _____

Directions:

Given a pan balance, Kurbro marker and a pair of school scissors, the student is to determine which is heavier. Check the student's answer and mark below if it is right or wrong.

Read Aloud:

Use the pan balance to find which object is heavier, the pair of scissors or the Kurbro marker. Answer the question below.

Which is heavier, the Kurbro marker or the pair of scissors?

Circle One: Kurbro Marker

Scissors

Circle One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.16.16.16

Grade 4

School _____

Date _____

Directions:

Given a micrometer and five index cards, the student is to determine the thickness of the five index cards. Check the student's answer and mark whether it is right or wrong below.

Read Aloud:

Use the micrometer and five index cards to tell how many millimeters thick five index cards are. Answer the question below.

Five index cards are _____ mm thick. .

Circle One: 2 8 10

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.17.17.17

Grade 4

School _____

Date _____

Directions:

Given a metric caliper the student is to measure the thickness of his/her Silver-Burdett mathematics text. Check his/her answer and mark whether it is right or wrong below.

Read Aloud:

Use the metric caliper to measure the thickness of your mathematics book. Complete the sentence below.

The mathematics text is about _____ cm thick.

Circle One: 1 cm 2 cm 4 cm

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.18.18.18

Grade 4

School _____

Date _____

Directions:

Given sufficient centimeter cubes and the squares below the student is to determine the number of centimeter cubes needed to fill the inside of the square. Check the student's answer and mark below whether it is right or wrong.

Read Aloud:

Use the centimeter cubes to measure the surface of the square below. Write your answer in the square.



Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.19.19.19

Grade 4

School _____

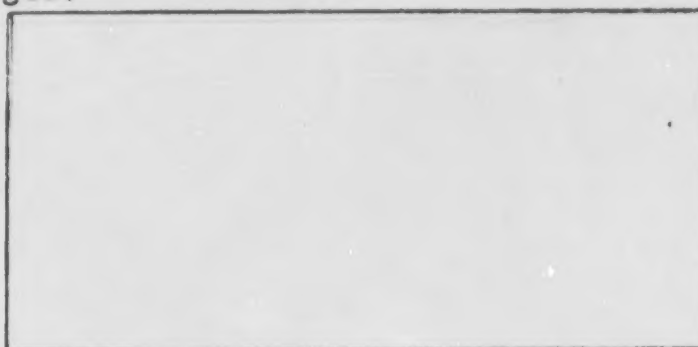
Date _____

Directions:

The student is to calculate the area of a rectangular surface given a metric ruler. Check his answer and mark below if it is right or wrong.

Read Aloud:

Use your metric ruler to find the area of the rectangle below and write your answer inside the rectangle.



Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.20.20.20

Grade 4

School _____

Date _____

Directions:

Given a trundle wheel or meter stick, the student is to measure the width of his classroom. Check his/her answer and mark below if it is right or wrong.

Read Aloud:

Use the trundle wheel or meter stick to measure the width of your classroom. Write your answer below.

Answer: _____ m

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.21.21.21

Grade 4

School _____

Date _____

Directions:

Given sufficient centimeter cubes, the student is to predict the number of units needed to make a square into a cube. Check the student's answer and mark below if it is right or wrong.

Read Aloud:

Use centimeter cubes to find the number of units needed to make the square below into a cube. Write your answer in the square below.



Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.22.22.22

Grade 4

School _____

Date _____

Directions:

The student is to draw from his "frame of reference" with respect to the capacity of a liter and to compare it with a quart. Check his answer and mark below if it is right or wrong.

Read Aloud:

Which is larger, the liter or the quart?

Mark One: Quart _____

Liter _____

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.23.23.23

Grade 4

School _____

Date _____

Directions:

The student is to use a pan balance, the pair of scissors provided, and the container of metric stacking masses to determine the least number of mass pieces needed to find the mass of the scissors. Check the student's answer and mark below if it is right or wrong.

Read Aloud:

Use the pan balance and the metric stacking masses to find the mass of the scissors by using the least number of mass pieces. Answer the question below.

It takes _____ mass pieces to balance the scissors on the pan balance.

Circle One: 1 4 2

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.24.24.24

Grade 4

School _____

Date _____

Directions:

The student is to write two factors that influence the boiling point of water. Check his/her answer and mark if it is right or wrong below.

Read Aloud:

Write below the two factors that influence the boiling point of water.

Answers: 1. _____

2. _____

Sugar

Salt

Stirring

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.25.25.25

Grade 4

School _____

Date _____

Directions:

The student is to write the one factor that lowers the freezing point of water. Check his/her answer and mark below if it is right or wrong.

Read Aloud:

Write below one factor that will lower the freezing point of water.

Answer: _____

Sugar

Salt

Pepper

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.26.26.26

Grade 5

School _____

Date _____

Teacher's Directions:

Given a metric ruler, the student is to measure the length of the footprint below. Check his/her answer and mark below if it is right or wrong.

Student's directions:

Use your ruler to measure the length of the footprint below. Write your answer on the line.



Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.27.27.27

Grade 5

School _____

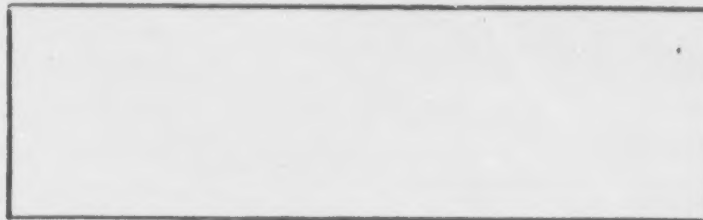
Date _____

Teacher's Directions:

Given a metric ruler, the student is to compute the area of the rectangle below. Check his/her answer and mark below if it is right or wrong.

Student's Directions:

Use your metric ruler to find the area of the rectangle below and write your answer inside the rectangle.



Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.28.28.28

Grade 5

School _____

Date _____

Teacher's Directions:

Given a trundle wheel or meter stick, the student is to measure the area of the classroom. Check his/her answer and write below if it is right or wrong.

Student's Directions:

Use the trundle wheel or meter stick to find the area of your classroom. Round off your answer to the nearest meter. Write your answer on the line below.

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.29.29.29

Grade 5

School _____

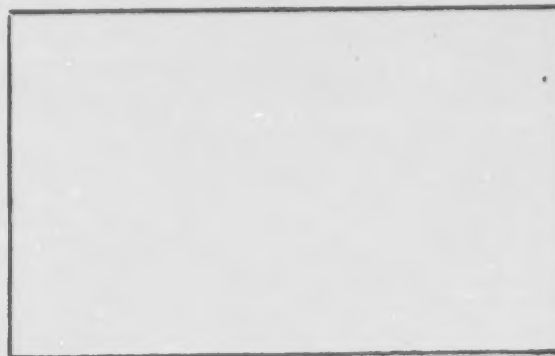
Date _____

Teacher's Directions:

Given a metric ruler the student is to determine the number of two centimeter squares inside the rectangle below. Check his answer and mark below if it is right or wrong.

Student's Directions:

Use your metric ruler to find how many two centimeter squares are inside the rectangle below. Write your answer inside the rectangle.



Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.30.30.30

Grade 5

School _____

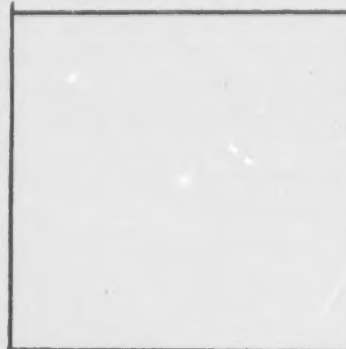
Date _____

Teacher's Directions:

The student is to determine the area of a square, by knowing the measurement of one side of a square. Check his answer and mark below if it is right or wrong.

Student's Directions:

Find the area of a square that has a measurement of five centimeters on one side of the square. Write your answer inside the square.



Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.31.31.31

Grade 5

School _____

Date _____

Teacher's Directions:

The student is to determine the capacity of a 7-ounce bottle in milliliters, given a graduated cylinder, water and a 7-ounce bottle. Check his/her answer and mark below if it is right or wrong.

Student's Directions:

Use the graduated cylinder, water and the 7-ounce bottle to find the capacity of the bottle in milliliters. Write your answer below.

Answer: _____

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.32.32.32

Grade 5

School _____

Date _____

Teacher's Directions:

The student is to find the volume of a box.
Check his answer and mark below if it is
right or wrong.

Student's Directions:

Find the volume of a box having a length of
15 centimeters, a width of 9 centimeters and
a height of 10 centimeters. Write your answer
on the line below.

Answer: _____

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.33.33.33

Grade 5

School _____

Date _____

Teacher's Directions:

The student is to use metric stacking masses, a balance and 10 centimeter cubes to measure the mass of the cubes. Check the student's answer below and mark if it is right or wrong.

Student's Directions:

Use the balance to measure the mass of 10 centimeter cubes. Circle the correct answer.

4 g

10 g

16 g

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.34.34.34

Grade 5

School _____

Date _____

Teacher's Directions:

Given a pan balance, metric stacking masses and water, the student is to find the relationship that exists between volume and mass. Check the student's answer and mark below if it is right or wrong.

Student's Directions:

Use the pan balance, water and metric stacking masses to answer the question below.

In order to have the water and mass pieces balance, how many ml of water must you put on one side of the pan balance if 100 g are put on the other side?

Circle One: 1000 ml 100 ml 10 ml

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.35.35.35

Grade 5

School _____

Date _____

Teacher's Directions:

The student is to list the Celsius temperature reading for four common temperatures. Check his/her answers and mark below. If three or more are correct put a mark by the word "right." If there are two or more errors, put a mark by the word "wrong."

Student's Directions:

Write on the lines below the Celsius temperature readings for the four common temperatures.

1. Boiling water _____
2. Freezing water _____
3. Room temperature _____
4. Body temperature _____

37

0

25

100

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.36.36.36

Grade 6

School _____

Date _____

Teacher's Directions:

Given a metric ruler the student is to make a metric scale drawing. One cm is to equal one m. Check the square and mark below if it is right or wrong.

Student's Directions:

Use a metric ruler to draw to scale a square having a side of four meters. One centimeter is to equal one meter. Make your square below.

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.37.37.37

Grade 6

School _____

Date _____

Teacher's Directions:

The student is to accurately determine the surface area of a rectangular solid. Check the answer and mark below if it is right or wrong.

Student's Directions:

Find the surface area of a rectangular solid having a length of 3 centimeters, a width of 2 centimeters and a height of 2 centimeters. Write your answer on the line below.

Answer: _____

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.38.38.38

Grade 6

School _____

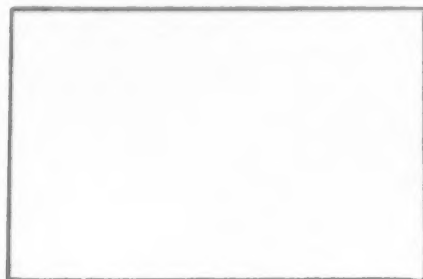
Date _____

Teacher's Directions:

The student is to determine the area and perimeter of a rectangle. Then he is to determine if there is a relationship between the perimeter and area of the rectangle. Check his three answers and mark below if they are all right. If one or more is wrong, mark where it says "wrong."

Student's Directions:

Write the perimeter and area of the rectangle on the lines below. Is there a relationship between the perimeter and area of the rectangle? Write yes or no inside the rectangle.



Perimeter: _____

Area: _____

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.39.39.39

Grade 6

School _____

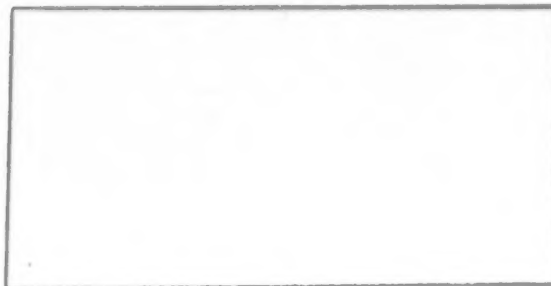
Date _____

Teacher's Directions:

The student is to find the area and perimeter of a rectangle. Check his answers and mark below if he has both answers right. If one or more answers are wrong, mark where it says "wrong."

Student's Directions:

Using your metric ruler, find the area and perimeter of the rectangle below. Write your answers on the lines below.



Area: _____

Perimeter: _____

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.40.40.40

Grade 6

School _____

Date _____

Teacher's Directions:

Given a graduated cylinder, water and a 7-ounce bottle, the student is to determine the metric capacity of the bottle. Check his answer and mark below if it is right or wrong.

Student's Directions:

Use the graduated cylinder, water and the 7-ounce bottle to determine the metric capacity of the bottle. Write your answer on the line below.

Answer: _____

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.41.41.41

Grade 6

School _____

Date _____

Teacher's Directions:

The student will be able to find the volume of a cube when the dimensions are tripled. Check his answer and mark below if it is right or wrong.

Student's Directions:

A cube is 1 m x 1 m x 1 m. Find the volume of the cube when each side is tripled. Write your answer on the line below. Use the test paper as a worksheet.

Answer: _____ m³

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.42.42.42

Grade 6

School _____

Date _____

Teacher's Directions:

Given a 50 ml beaker, 5 centicubes and 20 ml of water in the beaker, the student will determine the volume of one centicube in milliliters. Check the student's answer and mark below if it is right or wrong.

Student's Directions:

Use the 5 centicubes, 20 ml of water and the 50 ml beaker to find the volume of 1 centicube. Complete the sentence below.

The volume of 1 centicube is _____ ml.

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.43.43.43

Grade 6

School _____

Date _____

Teacher's Directions:

The student is to find the volume of a rectangular solid and a cylinder. Check the answers and put a mark below by the word "right" if both answers are correct. Put a mark by the word "wrong" if one or more answers are wrong.

Student's Directions:

1. Find the volume of a rectangular solid having a length of 10 m, a width of 3 m and a height of 4 m. Write your answer on the line below.
2. Find the volume of a cylinder having a diameter of 5 cm and a depth of 10 cm. Write your answer on the line below.

(Formula: $V = (3.14 \times d^2 \times h)/4$)

OR

$(V = 3.14 \times r^2 \times h)$

1. The volume of the rectangle is _____ cm³.
2. The volume of the cylinder is _____ ml.

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.44.44.44

Grade 6

School _____

Date _____

Teacher's Directions:

Given a balance, a pair of school scissors, and metric stacking masses the student is to determine the mass of the pair of scissors. Check the answer and mark below if it is right or wrong.

Student's Directions:

Use the pan balance, the metric stacking masses and the pair of scissors to find the mass of the pair of scissors. Answer the questions below.

The mass of the pair of scissors is _____ g.

Circle One: 35 g 20 g 40 g

Check One: Right _____

Wrong _____

IMPROVEMENT IN TEACHING METRICATION
BY MEANS OF
PERFORMANCE OBJECTIVES

TEST 1.45:45.45

Grade 6

School _____

Date _____

Teacher's Directions:

The student is to be able to relate Celsius temperature to everyday situations. Check his answers. Mark it right below if both answers are correct. If one or more answers are wrong, mark it wrong.

Student's Directions:

Look at the Celsius temperature below. Circle the temperature that would most likely be found in a classroom. Underline the temperature that means it is going to freeze.

167 25 100 10 0

Check One: Right _____

Wrong _____

APPENDIX G

LETTER FROM COORDINATOR OF
E.S.E.A. TITLE IV-B PROGRAM



COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF EDUCATION
BOX 911, HARRISBURG, PA. 17126

192

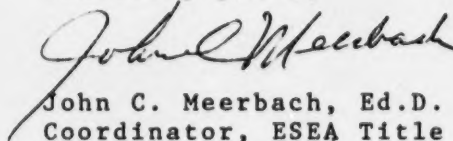
October 6, 1976

Mr. Thomas K. Rowles
Principal
Greenock School
Greenock-Buena Vista Road
McKeesport, Pennsylvania 15135

Dear Mr. Rowles:

The problems surrounding the release of Title IV-B funds for this year are being gradually resolved. Within the next week, Elizabeth Forward School District will receive a grant award approval for fiscal year 1976-77. This will permit you to encumber funds as of the date given in the grant award. I do not anticipate any further delays in the program beyond this point in time.

Sincerely yours,



John C. Meerbach, Ed.D.
Coordinator, ESEA Title IV-B
Bureau of Instructional Support Services

APPENDIX H
BIBLIOGRAPHY

Bates, John H. Exploring Metric Measure - Primary Teacher's Source Book. New York: McGraw-Hill, 1972.

Bitter, Gary G., and others. Activities Handbook for Teaching the Metric System. Boston: Allyn and Bacon, Inc., 1976.

Bitter, Gary G., and others. Discovering Metric Measure. New York: Mebster/McGraw Hill, 1975.

Branley, Franklyn M. "The Metric System." Grade Teacher. (December, 1959), pp. 49 and 100.

Brief History of Measurement Systems. National Bureau of Standards. Washington D.C.: Government Printing Office, 1972. p.4.

Buckeye, Donald A. I'm O.K.-You're O.K., Let's Go Metric. Troy, Michigan: Midwest Publications, 1973.

Buckeye, Donald A. Introducing the Metric System with Activities. Troy, Michigan: Midwest Publications, 1972.

Buckeye, Donald A. The Metric System with Activities. Troy, Michigan: Midwest Publications, 1973.

Buffington, Audrey V. Meters, Liters, and Grams. New York: Random House, 1973.

Hawkins, Virgil J. "Teaching the Metric System as Part of Compulsory Conversion in the U.S." The Arithmetic Teacher (May, 1973), pp. 390-394.

Immerzeel, George J. "Ideas". Arithmetic Teacher (April, 1973), pp. 280-287.

Immerzeel, George J., and Don Wiederanders. "Ideas for Teachers." Arithmetic Teacher (May, 1972), pp. 362-363.

Jeffries, Thomas W. "Teaching the Metric System." The Science Teacher (February, 1961), p. 53.

Miller, David M. Understanding the Metric System: A Programmed Approach. Boston: Allyn and Bacon, Inc., 1973.

BIBLIOGRAPHY
(cont.)

Piaget, Jean. "How Children Form Mathematical Concepts." Scientific American (November, 1953), p. 78.

Ploutz, Paul F. The Metric System: A Programmed Approach. Columbus, Ohio: Charles E. Merrill, 1972.

Shoecraft, Paul M. "The Foot, Quart and Pound Collide with Computation, U.S. Goes Metric." School Science and Mathematics (January 1974), pp. 67-68.

Trueblood, Cecil R. Metric Measurement. Dansville, New York: The Instructor Publications, 1973.